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(54) Title: GLYCOCONJUGATION USING SACCHARYL FRAGMENTS

(57) Abstract: The present invention provides conjugates between a substrate, e.g., peptide, glycopeptide, lipid, etc., and a modified saccharyl fragment bearing a modifying group such as a water-soluble polymer, therapeutic moiety or a biomolecule. The conjugates are linked via the enzymatic conversion of the activated modified saccharyl fragment into a glycosyl linking group that is interposed between and covalently attached to the substrate and the modifying group. The conjugates are formed from substrates by the action of a sugar transferring enzyme, e.g., a glycosyltransferase. For example, when the substrate is a peptide, the enzyme conjugates a modified saccharyl fragment moiety onto either an amino acid or glycosyl residue of the peptide. Also provided are pharmaceutical formulations that include the conjugates. Methods for preparing the conjugates are also within the scope of the invention.



**WO 2006/074279 A1**

## GLYCOCONJUGATION USING SACCHARYL FRAGMENTS

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to U.S. Provisional Patent Application  
5 60/641,956, filed January 6, 2005, which is incorporated by reference in its entirety for all purposes.

### BACKGROUND OF THE INVENTION

#### Field of the Invention

[0002] The present invention relates to conjugates formed between a biologically relevant  
10 substrate (e.g., a glycosylated or non-glycosylated peptide or lipid) and a saccharyl fragment that includes a modifying group ("modified fragment"). The substrate and modified fragment are linked through an enzymatically formed bond between the modified fragment and an acceptor moiety on the substrate.

#### Background

15 [0003] The administration of glycosylated and non-glycosylated therapeutic agents for engendering a particular physiological response is well known in the medicinal arts. For example, both purified and recombinant hGH are used for treating conditions and diseases due to hGH deficiency, e.g., dwarfism in children. Interferon has known antiviral activity and granulocyte colony stimulating factor stimulates the production of white blood cells.

20 [0004] A principal factor that has limited the use of therapeutic peptides is the difficulty inherent in engineering an expression system to express a peptide having the glycosylation pattern of the wild-type peptide. Improperly or incompletely glycosylated peptides can be immunogenic; in a patient, an immunogenic response to an administered peptide can neutralize the peptide and/or lead to the development of an allergic response in the patient.

25 Other deficiencies of recombinantly produced glycopeptides include suboptimal potency and rapid clearance rates. The problems inherent in peptide therapeutics are recognized in the art, and various methods of eliminating the problems have been investigated.

[0005] Post-expression *in vitro* modification of peptides is an attractive strategy to remedy the deficiencies of methods that rely on controlling glycosylation by engineering expression

systems; including both modification of glycan structures or introduction of glycans at novel sites. A comprehensive toolbox of recombinant eukaryotic glycosyltransferases is becoming available, making *in vitro* enzymatic synthesis of mammalian glycoconjugates with custom designed glycosylation patterns and glycosyl structures possible. See, for example, U.S.

5 Patent No. 5,876,980; 6,030,815; 5,728,554; 5,922,577; and WO/9831826; US2003180835; and WO 03/031464.

[0006] Enzyme-based syntheses have the advantages of regioselectivity and stereoselectivity. Moreover, enzymatic syntheses are performed using unprotected substrates. Two principal classes of enzymes are used in the synthesis of carbohydrates, glycosyltransferases (*e.g.*, sialyltransferases, oligosaccharyltransferases, N-acetylglucosaminyltransferases), and glycosidases. The glycosidases are further classified as exoglycosidases (*e.g.*,  $\beta$ -mannosidase,  $\beta$ -glucosidase), and endoglycosidases (*e.g.*, Endo-A, Endo-M). Each of these classes of enzymes has been successfully used synthetically to prepare carbohydrates. For a general review, *see*, Crout *et al.*, *Curr. Opin. Chem. Biol.* **2**: 98-111 (1998).

[0007] Glycosyltransferases modify the oligosaccharide structures on glycopeptides. Glycosyltransferases are effective for producing specific products with good stereochemical and regiochemical control. Glycosyltransferases have been used to prepare oligosaccharides and to modify terminal N- and O-linked carbohydrate structures, particularly on glycopeptides produced in mammalian cells. For example, the terminal oligosaccharides of glycopeptides have been completely sialylated and/or fucosylated to provide more consistent sugar structures, which improves glycopeptide pharmacodynamics and a variety of other biological properties. For example,  $\beta$ -1,4-galactosyltransferase was used to synthesize lactosamine, an illustration of the utility of glycosyltransferases in the synthesis of carbohydrates (*see, e.g.*, Wong *et al.*, *J. Org. Chem.* **47**: 5416-5418 (1982)). Moreover, numerous synthetic procedures have made use of  $\alpha$ -sialyltransferases to transfer sialic acid from cytidine-5'-monophospho-N-acetylneuraminic acid to the 3-OH or 6-OH of galactose (*see, e.g.*, Kevin *et al.*, *Chem. Eur. J.* **2**: 1359-1362 (1996)). Fucosyltransferases are used in synthetic pathways to transfer a fucose unit from guanosine-5'-diphosphofucose to a specific hydroxyl of a saccharide acceptor. For example, Ichikawa prepared sialyl Lewis-X by a method that involves the fucosylation of sialylated lactosamine with a cloned fucosyltransferase (Ichikawa *et al.*, *J. Am. Chem. Soc.* **114**: 9283-9298 (1992)). For a

discussion of recent advances in glycoconjugate synthesis for therapeutic use *see*, Koeller *et al.*, *Nature Biotechnology* **18**: 835-841 (2000). *See also*, U.S. Patent No. 5,876,980; 6,030,815; 5,728,554; 5,922,577; and WO/9831826.

[0008] Glycosidases can also be used to prepare saccharides. Glycosidases normally  
5 catalyze the hydrolysis of a glycosidic bond. Under appropriate conditions, however, they  
can be used to form this linkage. Most glycosidases used for carbohydrate synthesis are  
exoglycosidases; the glycosyl transfer occurs at the non-reducing terminus of the substrate.  
The glycosidase takes up a glycosyl donor in a glycosyl-enzyme intermediate that is either  
10 intercepted by water to give the hydrolysis product, or by an acceptor, to give a new  
glycoside or oligosaccharide. An exemplary pathway using an exoglycosidase is the  
synthesis of the core trisaccharide of all N-linked glycopeptides, including the difficult  $\beta$ -  
mannoside linkage, which was formed by the action of  $\beta$ -mannosidase (Singh *et al.*, *Chem.*  
*Commun.* 993-994 (1996)).

[0009] In another exemplary application of the use of a glycosidase to form a glycosidic  
15 linkage, a mutant glycosidase was prepared in which the normal nucleophilic amino acid  
within the active site is changed to a non-nucleophilic amino acid. The mutant enzymes do  
not hydrolyze glycosidic linkages, but can still form them. The mutant glycosidases are used  
to prepare oligosaccharides using an  $\alpha$ -glycosyl fluoride donor and a glycoside acceptor  
molecule (Withers *et al.*, U.S. Patent No. 5,716,812). Although the mutant glycosidases are  
20 useful for forming free oligosaccharides, it has yet to be demonstrated that such enzymes are  
capable of appending glycosyl donors onto glycosylated or non-glycosylated peptides, nor  
have these enzymes been used with unactivated glycosyl donors.

[0010] Although their use is less common than that of the exoglycosidases,  
endoglycosidases are also utilized to prepare carbohydrates. Methods based on the use of  
25 endoglycosidases have the advantage that an oligosaccharide, rather than a monosaccharide,  
is transferred. Oligosaccharide fragments have been added to substrates using *endo*- $\beta$ -N-  
acetylglucosamines such as *endo*-F, *endo*-M (Wang *et al.*, *Tetrahedron Lett.* **37**: 1975-1978);  
and Haneda *et al.*, *Carbohydr. Res.* **292**: 61-70 (1996)).

[0011] In addition to their use in preparing carbohydrates, the enzymes discussed above are  
30 applied to the synthesis of glycopeptides. The synthesis of a homogeneous glycoform of  
ribonuclease B has been published (Witte K. *et al.*, *J. Am. Chem. Soc.* **119**: 2114-2118

(1997)). The high mannose core of ribonuclease B was cleaved by treating the glycopeptide with endoglycosidase H. The cleavage occurred specifically between the two core GlcNAc residues. The tetrasaccharide sialyl Lewis X was then enzymatically rebuilt on the remaining GlcNAc anchor site on the now homogeneous protein by the sequential use of  $\beta$ -1,4-galactosyltransferase,  $\alpha$ -2,3-sialyltransferase and  $\alpha$ -1,3-fucosyltransferase V. Each enzymatically catalyzed step proceeded in excellent yield.

[0012] Methods combining both chemical and enzymatic synthetic elements are also known. For example, Yamamoto and coworkers (*Carbohydr. Res.* **305**: 415-422 (1998)) reported the chemoenzymatic synthesis of the glycopeptide, glycosylated Peptide T, using an endoglycosidase. The N-acetylglucosaminyl peptide was synthesized by purely chemical means. The peptide was subsequently enzymatically elaborated with the oligosaccharide of human transferrin glycopeptide. The saccharide portion was added to the peptide by treating it with an endo- $\beta$ -N-acetylglucosaminidase. The resulting glycosylated peptide was highly stable and resistant to proteolysis when compared to the peptide T and N-acetylglucosaminyl peptide T.

[0013] The use of glycosyltransferases to modify peptide structure with reporter groups has been explored. For example, Brossmer *et al.* (U.S. Patent No. 5,405,753) discloses the formation of a fluorescent-labeled cytidine monophosphate ("CMP") derivative of sialic acid and the use of the fluorescent glycoside in an assay for sialyl transferase activity and for the fluorescent labeling of cell surfaces, glycoproteins and gangliosides. Gross *et al.* (*Analyt. Biochem.* **186**: 127 (1990)) describe a similar assay. Bean *et al.* (U.S. Patent No. 5,432,059) discloses an assay for glycosylation deficiency disorders utilizing reglycosylation of a deficiently glycosylated protein. The deficient protein is reglycosylated with a fluorescent-labeled CMP glycoside. Each of the fluorescent sialic acid derivatives is substituted with the fluorescent moiety at either the 9-position or at the amine that is normally acetylated in sialic acid. The methods using the fluorescent sialic acid derivatives are assays for the presence of glycosyltransferases or for non-glycosylated or improperly glycosylated glycoproteins. The assays are conducted on small amounts of enzyme or glycoprotein in a sample of biological origin. The enzymatic derivatization of a glycosylated or non-glycosylated peptide on a preparative or industrial scale using a modified sialic acid has not been disclosed or suggested.

[0014] Considerable effort has also been directed towards the modification of cell surfaces by altering glycosyl residues presented by those surfaces. For example, Fukuda and coworkers have developed a method for attaching glycosides of defined structure onto cell surfaces. The method exploits the relaxed substrate specificity of a fucosyltransferase that can transfer fucose and fucose analogs bearing diverse glycosyl substrates (Tsuboi *et al.*, *J. Biol. Chem.* **271**: 27213 (1996)).

[0015] The methods of modifying cell surfaces have not been applied in the absence of a cell to modify a glycosylated or non-glycosylated peptide. Moreover, the methods of cell surface modification are not utilized for the enzymatic incorporation preformed modified glycosyl donor moiety into a peptide. Moreover, none of the cell surface modification methods are practical for producing glycosyl-modified peptides on an industrial scale.

[0016] Enzymatic methods have also been used to activate glycosyl residues on a glycopeptide towards subsequent chemical elaboration. The glycosyl residues are typically activated using galactose oxidase, which converts a terminal galactose residue to the corresponding aldehyde. The aldehyde is subsequently coupled to an amine-containing modifying group. For example, Casares *et al.* (*Nature Biotech.* **19**: 142 (2001)) have attached doxorubicin to the oxidized galactose residues of a recombinant MHCII-peptide chimera.

[0017] In addition to manipulating the structure of glycosyl groups on polypeptides, interest has developed in preparing glycopeptides that are modified with one or more non-saccharide modifying group, such as a water-soluble polymer. Poly(ethyleneglycol) ("PEG") is an exemplary polymer that has been conjugated to polypeptides. The use of PEG to derivatize peptide therapeutics has been demonstrated to reduce the immunogenicity of the peptides. For example, U.S. Pat. No. 4,179,337 (Davis *et al.*) discloses non-immunogenic polypeptides, such as enzymes and peptide hormones coupled to polyethylene glycol (PEG) or polypropylene glycol. Between 10 and 100 moles of polymer are used per mole polypeptide. Although the in vivo clearance time of the conjugate is prolonged relative to that of the polypeptide, only about 15% of the physiological activity is maintained. Thus, the prolonged circulation half-life is counterbalanced by the dramatic reduction in peptide potency.

[0018] The loss of peptide activity is directly attributable to the non-selective nature of the chemistries utilized to conjugate the water-soluble polymer. The principal mode of attachment of PEG, and its derivatives, to peptides is a non-specific bonding through a

peptide amino acid residue. For example, U.S. Patent No. 4,088,538 discloses an enzymatically active polymer-enzyme conjugate of an enzyme covalently bound to PEG. Similarly, U.S. Patent No. 4,496,689 discloses a covalently attached complex of  $\alpha$ -1 proteinase inhibitor with a polymer such as PEG or methoxypoly(ethyleneglycol) (“(m-) PEG”). Abuchowski *et al.* (*J. Biol. Chem.* **252**: 3578 (1977)) discloses the covalent attachment of (m-) PEG to an amine group of bovine serum albumin. U.S. Patent No. 4,414,147 discloses a method of rendering interferon less hydrophobic by conjugating it to an anhydride of a dicarboxylic acid, such as poly(ethylene succinic anhydride). PCT WO 87/00056 discloses conjugation of PEG and poly(oxyethylated) polyols to such proteins as interferon- $\beta$ , interleukin-2 and immunotoxins. EP 154,316 discloses and claims chemically modified lymphokines, such as IL-2 containing PEG bonded directly to at least one primary amino group of the lymphokine. U.S. Patent No. 4,055,635 discloses pharmaceutical compositions of a water-soluble complex of a proteolytic enzyme linked covalently to a polymeric substance such as a polysaccharide.

[0019] Another mode of attaching PEG to peptides is through the non-specific oxidation of glycosyl residues on a glycopeptide. The oxidized sugar is utilized as a locus for attaching a PEG moiety to the peptide. For example M’Timkulu (WO 94/05332) discloses the use of an amino-PEG to add PEG to a glycoprotein. The glycosyl moieties are randomly oxidized to the corresponding aldehydes, which are subsequently coupled to the amino-PEG.

[0020] In each of the methods described above, poly(ethyleneglycol) is added in a random, non-specific manner to reactive residues on a peptide backbone. For the production of therapeutic peptides, it is clearly desirable to utilize a derivatization strategy that results in the formation of a specifically labeled, readily characterizable, essentially homogeneous product. A promising route to preparing specifically labeled peptides is through the use of enzymes, such as glycosyltransferases to append a modified sugar moiety onto a peptide.

[0021] Glycosyl residues have also been modified to bear ketone groups. For example, Mahal and co-workers (*Science* **276**: 1125 (1997)) have prepared N-levulinoyl mannosamine (“ManLev”), which has a ketone functionality at the position normally occupied by the acetyl group in the natural substrate. Cells were treated with the ManLev, thereby incorporating a ketone group onto the cell surface. See, also Saxon *et al.*, *Science* **287**: 2007 (2000); Hang *et al.*, *J. Am. Chem. Soc.* **123**: 1242 (2001); Yarema *et al.*, *J. Biol. Chem.* **273**: 31168 (1998); and Charter *et al.*, *Glycobiology* **10**: 1049 (2000).

[0022] In addition to an industrially relevant method that utilizes the enzymatic conjugation to specifically conjugate a modified sugar to a peptide or glycopeptide, a method for controlling and manipulating the position of glycosylation on a glycopeptide would be highly desirable.

5 [0023] Carbohydrates are attached to glycopeptides in several ways of which N-linked to asparagine and mucin-type O-linked to serine and threonine are the most relevant for recombinant glycoprotein therapeutics. A determining factor for initiation of glycosylation of a protein is the primary sequence context, although clearly other factors including protein region and conformation play roles. N-linked glycosylation occurs at the consensus sequence  
10 NXS/T, where X can be any amino acid but proline.

[0024] O-linked glycosylation is initiated by a family of about 20 homologous enzymes termed UDP-GalNAc: polypeptide *N*-acetylgalactosaminyltransferases (GalNAc-transferases). O-linked glycosylation does not appear to be ruled by one simple consensus sequence, although studies of the GalNAc-transferase enzymes that initiate O-linked  
15 glycosylation clearly supports the notion that their acceptor specificities are driven by primary sequence contexts. Each of these enzymes transfer a single monosaccharide GalNAc to serine and threonine residues, but they transfer to different peptide sequences although they show a large degree of overlap in functions. It is envisioned that the substrate specificity of each GalNAc-transferase is ruled primarily by a linear short acceptor consensus sequence.

20 [0025] Recently, a method of producing an ester linked carbohydrate-peptide conjugate was described by Davis (WO 03/014371, published Feb. 20, 2003). In this publication, a vinyl ester amino acid group was reacted with a carbohydrate acyl acceptor in the presence of an enzyme such as a protease (such as a serine protease), lipase, esterase or acylase. At this time, however, no other substrates, e.g., glycopeptides, glycolipids, are known to conjugate  
25 with carbohydrate acyl acceptors under these conditions.

[0026] The present invention answers the need for modified therapeutic species in which a modified glycosyl moiety is conjugated onto N- or O-linked glycosylation sites of the peptides and other bioactive species, e.g., glycolipids, sphingosines, ceramides, etc. The invention provides a route to new therapeutic conjugates and addresses the need for more  
30 stable and therapeutically effective species. Moreover, despite the efforts directed toward the enzymatic elaboration of saccharide structures, there remains still a need for alternative industrially practical methods for the modification of therapeutic agents, e.g., peptides,



glycopeptides and lipids with modifying groups such as water-soluble polymers, therapeutic moieties, biomolecules and the like. Of particular interest are methods in which the modified peptide has improved properties, which enhance its use as a therapeutic or diagnostic agent. The present invention fulfills these and other needs.

## BRIEF SUMMARY OF THE INVENTION

[0027] Glycotherapeutics (e.g., glycopeptides and glycolipids) present a challenging target for recombinant production of therapeutics. For example, specific carbohydrate moieties are often indispensable for the function and favorable pharmacokinetic properties of glycopeptide therapeutics; however, many of the most robust expression systems produce glycopeptides with non-human glycosylation patterns. Incorrect glycosylation can produce a peptide that is inactive, aggregated, antigenic and/or has unfavorable pharmacokinetics. Accordingly, considerable efforts are expended to develop recombinant expression cell systems capable of producing glycoproteins with biologically appropriate carbohydrate structures. This approach is hampered by numerous shortcomings, including cost, and heterogeneity and limitations in glycan structures.

[0028] Post-expression, *in vitro* glyco-modification of glycotherapeutics, e.g., glycopeptides, is an attractive strategy to remedy the deficiencies of methods that rely on controlling glycosylation by engineering expression systems; including both modification of glycan structures or introduction of glycans at novel sites. A comprehensive toolbox of recombinant eukaryotic glycosyltransferases is becoming available, making *in vitro* enzymatic synthesis of glycoconjugates with custom designed glycosylation patterns and glycosyl structures possible. See, for example, U.S. Patent Nos. 5,876,980; 6,030,815; 5,728,554; and 5,922,577; and WO 98/31826; US03/180835; and WO 03/031464.

[0029] *In vitro* glycosylation offers a number of advantages compared to recombinant expression of glycoproteins of which custom design and higher degree of homogeneity of the glycosyl moiety are examples. Moreover, combining bacterial expression of glycotherapeutics with *in vitro* modification (or placement) of the glycosyl residue offers numerous advantages over traditional recombinant expression technology including reduced potential exposure to adventitious agents, increased homogeneity of product, and cost reduction.

[0030] Ideally, conjugates of therapeutic species, such as peptides and lipids, are obtained using methods that provide the conjugates in a reproducible and predictable manner.

Moreover, in forming the conjugates it is generally preferred that the site of conjugation between the therapeutic species and the modifying group is selected such that its modification  
5 does not adversely affect advantageous properties of the therapeutic species, e.g. activity, specificity, low antigenicity, low toxicity, etc.

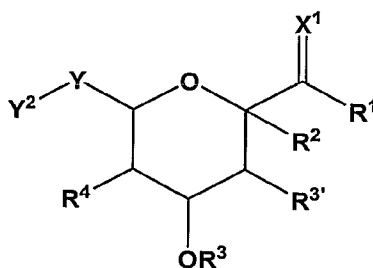
[0031] The present invention provides a method of forming conjugates between a glycosyl residue, amino acid or aglycone moiety of a selected substrate (e.g., (glyco)peptide, (glyco)lipid, etc.) and a modifying group, such as a water-soluble- or water-insoluble-  
10 polymer, a therapeutic moiety or a diagnostic agent. The invention exploits the recognition that saccharides, e.g., sialic acid, can be oxidized in a predictable and reproducible fashion, converting a primary or secondary hydroxyl moiety to an aldehyde or a ketone. The carbonyl moiety is readily modified with an amine-containing modifying group, affording a Schiff base, which is reduced to the corresponding amine modified saccharyl fragment. The  
15 fragment is recognized as a substrate by one or more enzyme capable of transferring a glycosyl moiety onto a substrate.

[0032] In an exemplary embodiment, the modified saccharyl fragment is a substrate for an enzyme that transfers a glycosyl donor moiety to a glycosyl acceptor. In an exemplary embodiment, the enzyme is a transferase, e.g., a sialyltransferase, which utilizes the modified  
20 fragment as a saccharyl donor in an enzymatically-mediated glycosylation reaction. In another embodiment, the enzyme is a mutant of a degradative enzyme, such as an exo- or endoglycosidase, amidase, etc.

[0033] In another embodiment, the modified saccharyl fragment is coupled to an intact saccharide residue. For example, coupling Sia\*-(modifying group) to galactose affords,  
25 Gal-Sia\*-(modifying group), which serves as a glycosyl donor that is added to a substrate, e.g. peptide, lipid, aglycone, etc.

[0034] The present invention is exemplified by reference to modified saccharyl fragments in which the side chain of a sialic acid is oxidized and the resulting carbonyl moiety (aldehyde) is converted to an amine by reductive amination with ammonia or an amine-  
30 containing modifying group. Those of skill will appreciate that saccharides, as a group, possess a rich oxidation chemistry that is readily exploited in variations on the exemplification of the invention presented herein.

[0035] In an exemplary aspect, the present invention provides a conjugate of a bioactive species, e.g., a peptide, nucleotide, activating moiety, carbohydrate, lipid (e.g., ceramide or sphingosine) that includes a subunit according to Formula I:



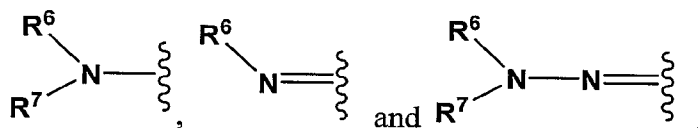
(I).

5 [0036] In Formula I, the symbol  $X^1$  represents substituted or unsubstituted alkyl, O or  $NR^8$ .  $R^8$  is a member selected from H, OH, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl. Appropriate  $R^1$  groups are selected from  $OR^9$ ,  $NR^9R^{10}$ , substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl. The symbols  $R^9$  and  $R^{10}$  independently represent H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl and  $C(O)R^{11}$ .  $R^{11}$  is a group such as substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl and substituted or unsubstituted heterocycloalkyl.

15 [0037] The symbol  $R^2$  is a member selected from a nucleotide, an activating moiety, an amino acid residue of a peptide, a carbohydrate moiety attached to an amino acid residue of a peptide through a linker and a carbohydrate moiety attached to an amino acid residue of a peptide through a linker comprising at least a second carbohydrate moiety. Exemplary linkers include one or more additional carbohydrate moieties in addition to that of  $R^2$ .  $R^3$  is a member selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl. The symbols  $R^4$  and  $R^{3'}$  independently represent H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, OH,  $OR^{4'}$  and  $NHC(O)R^{12}$ .  $R^{4'}$  is a member selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl.  $R^{12}$  is a member selected from substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, substituted or unsubstituted heterocycloalkyl and  $NR^{13}R^{14}$ , in which  $R^{13}$  and  $R^{14}$  are members independently selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl.

[0038] Y is the residue of the sialic acid side chain remaining following oxidation to a carbonyl and subsequent reaction of the carbonyl moiety with a nucleophilic group, alternatively followed by additional modifications. Exemplary groups for Y include CH<sub>2</sub>, CH(OH)CH<sub>2</sub>, CH(OH)CH(OH)CH<sub>2</sub> when the oxidation leads to formation of an aldehyde that is subsequently reductively aminated. When the aldehyde is converted to an imine species or is reacted with a phosphorus ylide, Y is typically CH, CH(OH)CH or CH(OH)CH(OH)CH. When the aldehyde is reacted with a Grignard or lithium reagent, exemplary Y groups include CH(OH), CH(OH)CH(OH), CH(OH)CH(OH)CH(OH) or an elimination product thereof, e.g., dehydration product.

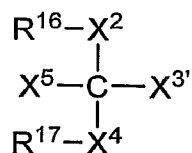
[0039] The symbol Y<sup>2</sup> represents groups formed by addition to the carbonyl moiety of the fragment. Y<sup>2</sup> includes at least one modifying group e.g., biomolecule, therapeutic moiety, diagnostic moiety, and a polymeric modifying group, as exemplified by the term R<sup>6a</sup>. Exemplary identities for Y<sup>2</sup> include substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl (e.g., formed by Wittig, Grignard or other appropriate chemistries), R<sup>6</sup>, and nitrogen-containing species, e.g.,



In an exemplary embodiment, Y<sup>2</sup> is a member selected from substituted alkyl, substituted or unsubstituted heteroalkyl, R<sup>6</sup>, and nitrogen-containing species. R<sup>6</sup> and R<sup>7</sup> are independently H, C(O)R<sup>6b</sup> or -L<sup>a</sup>-R<sup>6b</sup> wherein R<sup>6b</sup> is H or R<sup>6a</sup> and L<sup>a</sup> is selected from a bond and a linker group.

[0040] When Y<sup>2</sup> is substituted or unsubstituted alkyl, e.g., an alkene species formed by a Wittig reaction, or saturated species formed by Grignard or lithium chemistries, Y<sup>2</sup> includes at least one modifying group (water-soluble or -insoluble polymer) as exemplified by the term R<sup>6a</sup>.

[0041] As discussed herein, R<sup>6a</sup> can be a polymeric modifying group. Preferred polymeric modifying groups include PEG. The PEG of use in the conjugates of the invention can be linear or branched. An exemplary precursor of use to form the branched PEG containing peptide conjugates according to this embodiment of the invention has the formula:

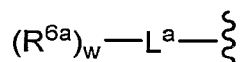


(II).

The branched polymer species according to this formula are essentially pure polymeric modifying groups.  $X^{3'}$  is a moiety that includes an ionizable (*e.g.*, OH, COOH, H<sub>2</sub>PO<sub>4</sub>, HSO<sub>3</sub>, NH<sub>2</sub>, and salts thereof, etc.) or other reactive functional group, *e.g.*, *infra*. C is carbon.

5  $X^5$ ,  $R^{16}$  and  $R^{17}$  are independently selected from non-reactive groups (*e.g.*, H, unsubstituted alkyl, unsubstituted heteroalkyl) and polymeric arms (*e.g.*, PEG).  $X^2$  and  $X^4$  are linkage fragments that are preferably essentially non-reactive under physiological conditions and that may be the same or different. An exemplary linker includes neither aromatic nor ester moieties. Alternatively, these linkages can include one or more moiety that is designed to  
10 degrade under physiologically relevant conditions, *e.g.*, esters, disulfides, etc.  $X^2$  and  $X^4$  join polymeric arms  $R^{16}$  and  $R^{17}$  to C. When  $X^{3'}$  is reacted with a reactive functional group of complementary reactivity on a linker, sugar or linker-sugar cassette,  $X^{3'}$  is converted to a component of linkage fragment  $X^3$ .

[0042] In an exemplary embodiment, the polymeric modifying group is bound to the  
15 glycosyl linking group, through a linker,  $L^a$ , in which case the residues  $R^6$  and  $R^7$  are independently as shown below:



$R^{6a}$  is the polymeric modifying group and  $L^a$  is selected from a bond and a linking group. The index w represents an integer selected from 1-6, preferably 1-3 and more preferably 1-2.  
20 Exemplary linking groups include substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl moieties. An exemplary component of the linker group is an acyl moiety. Another exemplary linking group is an amino acid (*e.g.*, cysteine, serine, lysine, and short oligopeptides, *e.g.*, Lys-Lys, Lys-Lys-Lys, Cys-Lys, Ser-Lys, etc.).

[0043] When  $L^a$  is a bond, it is formed by reaction of a reactive functional group on a  
25 precursor of  $R^{6a}$  and a reactive functional group of complementary reactivity on a precursor of the glycosyl linking group. When  $L^a$  is a non-zero order linking group, L can be in place on the glycosyl moiety prior to reaction with the  $R^{6a}$  precursor. Alternatively, the precursors of  $R^{6a}$  and  $L^a$  can be incorporated into a preformed cassette that is subsequently attached to the glycosyl moiety. As set forth herein, the selection and preparation of precursors with

appropriate reactive functional groups is within the ability of those skilled in the art. Moreover, coupling of the precursors proceeds by chemistry that is well understood in the art.

[0044] In another aspect, the invention provides an activated glycosyl linking group that is of use in the methods of the invention. In an exemplary embodiment, according to this aspect, the glycosyl linking group has a structure according to Formula I in which  $R^2$  is a nucleotide, forming a nucleotide sugar in which the sugar moiety is, or includes, the saccharyl fragment.  $R^2$  can also be a leaving group (activating group), such as a halogen, sulfonate ester and the like.

[0045] In a third aspect, the invention provides a peptide or lipid conjugate having a population of water-soluble polymer moieties covalently bound thereto through a glycosyl linking group that includes a moiety according to Formula I. In the conjugate of the invention, essentially each member of the population is bound via a glycosyl linking group, that includes a subunit according to Formula I, to an amino acid or glycosyl residue of the peptide, and each amino acid or glycosyl residue to which the linking group is bound has the same structure.

[0046] In a fourth aspect, the invention provides a method of forming a covalent conjugate between a polymer, e.g., water-soluble polymer, and saccharyl acceptor that is a glycosylated-peptide or -lipid, or a non-glycosylated-peptide or -lipid. The polymer is conjugated to the acceptor via a glycosyl linking group that includes a moiety according to Formula I. The glycosyl linking group is interposed between, and covalently linked either directly or indirectly to both the acceptor and the polymer. The method includes contacting the acceptor with a mixture containing a modified saccharyl fragment, generally activated as the nucleotide derivative, and an enzyme for which the modified saccharyl fragment is a substrate. The mixture also includes an enzyme that transfers a saccharyl residue, for which the modified saccharyl fragment is a substrate. The reaction is conducted under conditions appropriate to form the conjugate. See, for example WO03/031464 and related U.S. and PCT applications.

[0047] In a fifth aspect, the invention provides a conjugate analogous to those described above, in which the modified saccharyl fragment is derivatized with a therapeutic or diagnostic moiety. In an exemplary embodiment, the modifying group is a biomolecule, which can be a therapeutic or diagnostic agent.

[0048] In a further aspect, the present invention provides a composition for forming a conjugate between a peptide or lipid and a modified saccharyl fragment. The composition generally includes an activated analogue of the saccharyl fragment set forth in Formula I, an enzyme for which the activated glycosyl linking group is a substrate, and a (glyco)peptide or (glyco)lipid acceptor substrate. The glycosyl linking group has covalently attached thereto a member selected from water-soluble polymers, therapeutic moieties and biomolecules.

[0049] Also provided is a pharmaceutical composition. The composition includes a pharmaceutically acceptable carrier and a conjugate of the invention in admixture with a pharmaceutically acceptable carrier.

[0050] Other objects and advantages of the invention will be apparent to those of skill in the art from the detailed description that follows.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0051] FIG. 1 is a table of peptides to which the modified saccharyl fragment can be attached.

[0052] FIG. 2 is a table of sialyltransferases of use in practicing the present invention.

### DETAILED DESCRIPTION OF THE INVENTION AND THE PREFERRED EMBODIMENTS

#### Abbreviations

[0053] Branched or un-branched PEG, poly(ethyleneglycol), including m-PEG, methoxy-poly(ethylene glycol); branched or unbranched PPG, poly(propyleneglycol); m-PPG, methoxy-poly(propylene glycol); Fuc, fucosyl; Gal, galactosyl; GalNAc, N-acetylgalactosaminyl; Glc, glucosyl; GlcNAc, N-acetylglucosaminyl; Man, mannosyl; ManAc, mannosaminyl acetate; Sia, sialic acid; NeuAc, N-acetylneuraminyl; and SA\*-Y, sialic acid fragment, wherein SA\* is the glycosidic core or ring structure of the molecule and Y is part of the modified sialic acid side chain.

#### Definitions

[0054] Unless defined otherwise, all technical and scientific terms used herein generally have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Generally, the nomenclature used herein and the laboratory

procedures in cell culture, molecular genetics, organic chemistry and nucleic acid chemistry and hybridization are those well known and commonly employed in the art. Standard techniques are used for nucleic acid and peptide synthesis. The techniques and procedures are generally performed according to conventional methods in the art and various general references (*see generally*, Sambrook *et al.* MOLECULAR CLONING: A LABORATORY MANUAL, 2d ed. (1989) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., which is incorporated herein by reference), which are provided throughout this document. The nomenclature used herein and the laboratory procedures in analytical chemistry, and organic synthetic described below are those well known and commonly employed in the art. Standard techniques, or modifications thereof, are used for chemical syntheses and chemical analyses.

[0055] The term “alkyl,” by itself or as part of another substituent, means, unless otherwise stated, a straight or branched chain, or cyclic hydrocarbon radical, or combination thereof, which may be fully saturated, mono- or polyunsaturated and can include di- and multivalent radicals, having the number of carbon atoms designated (*i.e.* C<sub>1</sub>-C<sub>10</sub> means one to ten carbons). Examples of saturated hydrocarbon radicals include, but are not limited to, groups such as methyl, ethyl, n-propyl, isopropyl, n-butyl, t-butyl, isobutyl, sec-butyl, cyclohexyl, (cyclohexyl)methyl, cyclopropylmethyl, homologs and isomers of, for example, n-pentyl, n-hexyl, n-heptyl, n-octyl, and the like. An unsaturated alkyl group is one having one or more double bonds or triple bonds. Examples of unsaturated alkyl groups include, but are not limited to, vinyl, 2-propenyl, crotyl, 2-isopentenyl, 2-(butadienyl), 2,4-pentadienyl, 3-(1,4-pentadienyl), ethynyl, 1- and 3-propynyl, 3-butylnyl, and the higher homologs and isomers. The term “alkyl,” unless otherwise noted, is also meant to include those derivatives of alkyl defined in more detail below, such as “heteroalkyl.” Alkyl groups, which are limited to hydrocarbon groups are termed “homoalkyl”.

[0056] The term “alkylene” by itself or as part of another substituent means a divalent radical derived from an alkane, as exemplified, but not limited, by -CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>-, and further includes those groups described below as “heteroalkylene.” Typically, an alkyl (or alkylene) group will have from 1 to 24 carbon atoms, with those groups having 10 or fewer carbon atoms being preferred in the present invention. A “lower alkyl” or “lower alkylene” is a shorter chain alkyl or alkylene group, generally having eight or fewer carbon atoms.



[0057] The terms “alkoxy,” “alkylamino” and “alkylthio” (or thioalkoxy) are used in their conventional sense, and refer to those alkyl groups attached to the remainder of the molecule via an oxygen atom, an amino group, or a sulfur atom, respectively.

[0058] The term “heteroalkyl,” by itself or in combination with another term, means, unless otherwise stated, a stable straight or branched chain, or cyclic hydrocarbon radical, or combinations thereof, consisting of the stated number of carbon atoms and at least one heteroatom selected from the group consisting of O, N, Si and S, and wherein the nitrogen and sulfur atoms may optionally be oxidized and the nitrogen heteroatom may optionally be quaternized. The heteroatom(s) O, N and S and Si may be placed at any interior position of the heteroalkyl group or at the position at which the alkyl group is attached to the remainder of the molecule. Examples include, but are not limited to,  $-\text{CH}_2-\text{CH}_2-\text{O}-\text{CH}_3$ ,  $-\text{CH}_2-\text{CH}_2-\text{NH}-\text{CH}_3$ ,  $-\text{CH}_2-\text{CH}_2-\text{N}(\text{CH}_3)-\text{CH}_3$ ,  $-\text{CH}_2-\text{S}-\text{CH}_2-\text{CH}_3$ ,  $-\text{CH}_2-\text{CH}_2-\text{S}(\text{O})-\text{CH}_3$ ,  $-\text{CH}_2-\text{CH}_2-\text{S}(\text{O})_2-\text{CH}_3$ ,  $-\text{CH}=\text{CH}-\text{O}-\text{CH}_3$ ,  $-\text{Si}(\text{CH}_3)_3$ ,  $-\text{CH}_2-\text{CH}=\text{N}-\text{OCH}_3$ , and  $-\text{CH}=\text{CH}-\text{N}(\text{CH}_3)-\text{CH}_3$ . Up to two heteroatoms may be consecutive, such as, for example,  $-\text{CH}_2-\text{NH}-\text{OCH}_3$  and  $-\text{CH}_2-\text{O}-\text{Si}(\text{CH}_3)_3$ . Similarly, the term “heteroalkylene” by itself or as part of another substituent means a divalent radical derived from heteroalkyl, as exemplified, but not limited by,  $-\text{CH}_2-\text{CH}_2-\text{S}-\text{CH}_2-\text{CH}_2-$  and  $-\text{CH}_2-\text{S}-\text{CH}_2-\text{CH}_2-\text{NH}-\text{CH}_2-$ . For heteroalkylene groups, heteroatoms can also occupy either or both of the chain termini (*e.g.*, alkyleneoxy, alkyleneedioxy, alkyleneamino, alkylene-diamino, and the like). Still further, for alkylene and heteroalkylene linking groups, no orientation of the linking group is implied by the direction in which the formula of the linking group is written. For example, the formula  $-\text{C}(\text{O})_2\text{R}'$  represents both  $-\text{C}(\text{O})_2\text{R}'$  and  $-\text{R}'\text{C}(\text{O})_2-$ .

[0059] In general, an “acyl substituent” is also selected from the group set forth above. As used herein, the term “acyl substituent” refers to groups attached to, and fulfilling the valence of a carbonyl carbon that is either directly or indirectly attached to the polycyclic nucleus of the compounds of the present invention.

[0060] The terms “cycloalkyl” and “heterocycloalkyl”, by themselves or in combination with other terms, represent, unless otherwise stated, cyclic versions of “alkyl” and “heteroalkyl”, respectively. Additionally, for heterocycloalkyl, a heteroatom can occupy the position at which the heterocycle is attached to the remainder of the molecule. Examples of cycloalkyl include, but are not limited to, cyclopentyl, cyclohexyl, 1-cyclohexenyl, 3-cyclohexenyl, cycloheptyl, and the like. Examples of heterocycloalkyl include, but are not

limited to, 1-(1,2,5,6-tetrahydropyridyl), 1-piperidinyl, 2-piperidinyl, 3-piperidinyl, 4-morpholinyl, 3-morpholinyl, tetrahydrofuran-2-yl, tetrahydrofuran-3-yl, tetrahydrothien-2-yl, tetrahydrothien-3-yl, 1-piperazinyl, 2-piperazinyl, and the like.

[0061] The terms "halo" or "halogen," by themselves or as part of another substituent, mean, unless otherwise stated, a fluorine, chlorine, bromine, or iodine atom. Additionally, terms such as "haloalkyl," are meant to include monohaloalkyl and polyhaloalkyl. For example, the term "halo(C<sub>1</sub>-C<sub>4</sub>)alkyl" is meant to include, but not be limited to, trifluoromethyl, 2,2,2-trifluoroethyl, 4-chlorobutyl, 3-bromopropyl, and the like.

[0062] The term "aryl" means, unless otherwise stated, a polyunsaturated, aromatic, hydrocarbon substituent which can be a single ring or multiple rings (preferably from 1 to 3 rings) which are fused together or linked covalently. The term "heteroaryl" refers to aryl groups (or rings) that contain from one to four heteroatoms selected from N, O, and S, wherein the nitrogen and sulfur atoms are optionally oxidized, and the nitrogen atom(s) are optionally quaternized. A heteroaryl group can be attached to the remainder of the molecule through a heteroatom. Non-limiting examples of aryl and heteroaryl groups include phenyl, 1-naphthyl, 2-naphthyl, 4-biphenyl, 1-pyrrolyl, 2-pyrrolyl, 3-pyrrolyl, 3-pyrazolyl, 2-imidazolyl, 4-imidazolyl, pyrazinyl, 2-oxazolyl, 4-oxazolyl, 2-phenyl-4-oxazolyl, 5-oxazolyl, 3-isoxazolyl, 4-isoxazolyl, 5-isoxazolyl, 2-thiazolyl, 4-thiazolyl, 5-thiazolyl, 2-furyl, 3-furyl, 2-thienyl, 3-thienyl, 2-pyridyl, 3-pyridyl, 4-pyridyl, 2-pyrimidyl, 4-pyrimidyl, 5-benzothiazolyl, purinyl, 2-benzimidazolyl, 5-indolyl, 1-isoquinolyl, 5-isoquinolyl, 2-quinoxalyl, 5-quinoxalyl, 3-quinolyl, and 6-quinolyl. Substituents for each of the above noted aryl and heteroaryl ring systems are selected from the group of acceptable substituents described below.

[0063] For brevity, the term "aryl" when used in combination with other terms (*e.g.*, aryloxy, arylthioxy, arylalkyl) includes both aryl and heteroaryl rings as defined above. Thus, the term "arylalkyl" is meant to include those radicals in which an aryl group is attached to an alkyl group (*e.g.*, benzyl, phenethyl, pyridylmethyl and the like) including those alkyl groups in which a carbon atom (*e.g.*, a methylene group) has been replaced by, for example, an oxygen atom (*e.g.*, phenoxymethyl, 2-pyridyloxymethyl, 3-(1-naphthyloxy)propyl, and the like).

[0064] Each of the above terms (*e.g.*, “alkyl,” “heteroalkyl,” “aryl” and “heteroaryl”) include both substituted and unsubstituted forms of the indicated radical. Preferred substituents for each type of radical are provided below.

[0065] Substituents for the alkyl, and heteroalkyl radicals (including those groups often referred to as alkylene, alkenyl, heteroalkylene, heteroalkenyl, alkynyl, cycloalkyl, heterocycloalkyl, cycloalkenyl, and heterocycloalkenyl) are generally referred to as “alkyl substituents” and “heteroalkyl substituents,” respectively, and they can be one or more of a variety of groups selected from, but not limited to: -OR', =O, =NR', =N-OR', -NR'R'', -SR', -halogen, -SiR'R''R''', -OC(O)R', -C(O)R', -CO<sub>2</sub>R', -CONR'R'', -OC(O)NR'R'', -NR''C(O)R', -NR'-C(O)NR''R''', -NR''C(O)<sub>2</sub>R', -NR-C(NR'R''R''')=NR''', -NR-C(NR'R'')=NR''', -S(O)R', -S(O)<sub>2</sub>R', -S(O)<sub>2</sub>NR'R'', -NRSO<sub>2</sub>R', -CN and -NO<sub>2</sub> in a number ranging from zero to (2m'+1), where m' is the total number of carbon atoms in such radical. R', R'', R''' and R'''' each preferably independently refer to hydrogen, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, *e.g.*, aryl substituted with 1-3 halogens, substituted or unsubstituted alkyl, alkoxy or thioalkoxy groups, or arylalkyl groups. When a compound of the invention includes more than one R group, for example, each of the R groups is independently selected as are each R', R'', R''' and R'''' groups when more than one of these groups is present. When R' and R'' are attached to the same nitrogen atom, they can be combined with the nitrogen atom to form a 5-, 6-, or 7-membered ring. For example, -NR'R'' is meant to include, but not be limited to, 1-pyrrolidinyl and 4-morpholinyl. From the above discussion of substituents, one of skill in the art will understand that the term “alkyl” is meant to include groups including carbon atoms bound to groups other than hydrogen groups, such as haloalkyl (*e.g.*, -CF<sub>3</sub> and -CH<sub>2</sub>CF<sub>3</sub>) and acyl (*e.g.*, -C(O)CH<sub>3</sub>, -C(O)CF<sub>3</sub>, -C(O)CH<sub>2</sub>OCH<sub>3</sub>, and the like).

[0066] Similar to the substituents described for the alkyl radical, the aryl substituents and heteroaryl substituents are generally referred to as “aryl substituents” and “heteroaryl substituents,” respectively and are varied and selected from, for example: halogen, -OR', =O, =NR', =N-OR', -NR'R'', -SR', -halogen, -SiR'R''R''', -OC(O)R', -C(O)R', -CO<sub>2</sub>R', -CONR'R'', -OC(O)NR'R'', -NR''C(O)R', -NR'-C(O)NR''R''', -NR''C(O)<sub>2</sub>R', -NR-C(NR'R'')=NR''', -S(O)R', -S(O)<sub>2</sub>R', -S(O)<sub>2</sub>NR'R'', -NRSO<sub>2</sub>R', -CN and -NO<sub>2</sub>, -R', -N<sub>3</sub>, -CH(Ph)<sub>2</sub>, fluoro(C<sub>1</sub>-C<sub>4</sub>)alkoxy, and fluoro(C<sub>1</sub>-C<sub>4</sub>)alkyl, in a number ranging from zero to the total number of open valences on the aromatic ring system; and where R', R'', R''' and

R''' are preferably independently selected from hydrogen, (C<sub>1</sub>-C<sub>8</sub>)alkyl and heteroalkyl, unsubstituted aryl and heteroaryl, (unsubstituted aryl)-(C<sub>1</sub>-C<sub>4</sub>)alkyl, and (unsubstituted aryl)oxy-(C<sub>1</sub>-C<sub>4</sub>)alkyl. When a compound of the invention includes more than one R group, for example, each of the R groups is independently selected as are each R', R'', R''' and R'''' groups when more than one of these groups is present.

[0067] Two of the aryl substituents on adjacent atoms of the aryl or heteroaryl ring may optionally be replaced with a substituent of the formula -T-C(O)-(CRR')<sub>q</sub>-U-, wherein T and U are independently -NR-, -O-, -CRR'- or a single bond, and q is an integer of from 0 to 3. Alternatively, two of the substituents on adjacent atoms of the aryl or heteroaryl ring may optionally be replaced with a substituent of the formula -A-(CH<sub>2</sub>)<sub>r</sub>-B-, wherein A and B are independently -CRR'-, -O-, -NR-, -S-, -S(O)-, -S(O)<sub>2</sub>-, -S(O)<sub>2</sub>NR'- or a single bond, and r is an integer of from 1 to 4. One of the single bonds of the new ring so formed may optionally be replaced with a double bond. Alternatively, two of the substituents on adjacent atoms of the aryl or heteroaryl ring may optionally be replaced with a substituent of the formula - (CRR')<sub>s</sub>-X-(CR''R''')<sub>d</sub>-, where s and d are independently integers of from 0 to 3, and X is -O-, -NR'-, -S-, -S(O)-, -S(O)<sub>2</sub>-, or -S(O)<sub>2</sub>NR'-. The substituents R, R', R'' and R''' are preferably independently selected from hydrogen or substituted or unsubstituted (C<sub>1</sub>-C<sub>6</sub>)alkyl.

[0068] As used herein, the term "heteroatom" includes oxygen (O), nitrogen (N), sulfur (S) and silicon (Si).

[0069] The term "nucleic acid" or "polynucleotide" refers to deoxyribonucleic acids (DNA) or ribonucleic acids (RNA) and polymers thereof in either single- or double-stranded form. Unless specifically limited, the term encompasses nucleic acids containing known analogues of natural nucleotides that have similar binding properties as the reference nucleic acid and are metabolized in a manner similar to naturally occurring nucleotides. Unless otherwise indicated, a particular nucleic acid sequence also implicitly encompasses conservatively modified variants thereof (*e.g.*, degenerate codon substitutions), alleles, orthologs, SNPs, and complementary sequences as well as the sequence explicitly indicated. Specifically, degenerate codon substitutions may be achieved by generating sequences in which the third position of one or more selected (or all) codons is substituted with mixed-base and/or deoxyinosine residues (Batzer *et al.*, *Nucleic Acid Res.* **19**:5081 (1991); Ohtsuka *et al.*, *J. Biol. Chem.* **260**:2605-2608 (1985); and Rossolini *et al.*, *Mol. Cell. Probes* **8**:91-98

(1994)). The term nucleic acid is used interchangeably with gene, cDNA, and mRNA encoded by a gene.

[0070] The term “gene” means the segment of DNA involved in producing a polypeptide chain. It may include regions preceding and following the coding region (leader and trailer) as well as intervening sequences (introns) between individual coding segments (exons).

[0071] The term “amino acid” refers to naturally occurring and synthetic amino acids, as well as amino acid analogs and amino acid mimetics that function in a manner similar to the naturally occurring amino acids. Naturally occurring amino acids are those encoded by the genetic code, as well as those amino acids that are later modified, *e.g.*, hydroxyproline,  $\gamma$ -carboxyglutamate, and O-phosphoserine. Amino acid analogs refers to compounds that have the same basic chemical structure as a naturally occurring amino acid, *i.e.*, an  $\alpha$  carbon that is bound to a hydrogen, a carboxyl group, an amino group, and an R group, *e.g.*, homoserine, norleucine, methionine sulfoxide, methionine methyl sulfonium. Such analogs have modified R groups (*e.g.*, norleucine) or modified peptide backbones, but retain the same basic chemical structure as a naturally occurring amino acid. “Amino acid mimetics” refers to chemical compounds that have a structure that is different from the general chemical structure of an amino acid, but functioning in a manner similar to a naturally occurring amino acid.

[0072] Amino acids may be referred to herein by either the commonly known three letter symbols or by the one-letter symbols recommended by the IUPAC-IUB Biochemical Nomenclature Commission. Nucleotides, likewise, may be referred to by their commonly accepted single-letter codes.

[0073] “Conservatively modified variants” applies to both amino acid and nucleic acid sequences. With respect to particular nucleic acid sequences, “conservatively modified variants” refers to those nucleic acids that encode identical or essentially identical amino acid sequences, or where the nucleic acid does not encode an amino acid sequence, to essentially identical sequences. Because of the degeneracy of the genetic code, a large number of functionally identical nucleic acids encode any given protein. For instance, the codons GCA, GCC, GCG and GCU all encode the amino acid alanine. Thus, at every position where an alanine is specified by a codon, the codon can be altered to any of the corresponding codons described without altering the encoded polypeptide. Such nucleic acid variations are “silent variations,” which are one species of conservatively modified variations. Every nucleic acid sequence herein that encodes a polypeptide also describes every possible silent variation of

the nucleic acid. One of skill will recognize that each codon in a nucleic acid (except AUG, which is ordinarily the only codon for methionine, and TGG, which is ordinarily the only codon for tryptophan) can be modified to yield a functionally identical molecule.

Accordingly, each silent variation of a nucleic acid that encodes a polypeptide is implicit in each described sequence.

[0074] As to amino acid sequences, one of skill will recognize that individual substitutions, deletions or additions to a nucleic acid, peptide, polypeptide, or protein sequence which alters, adds or deletes a single amino acid or a small percentage of amino acids in the encoded sequence is a "conservatively modified variant" where the alteration results in the substitution of an amino acid with a chemically similar amino acid. Conservative substitution tables providing functionally similar amino acids are well known in the art. Such conservatively modified variants are in addition to and do not exclude polymorphic variants, interspecies homologs, and alleles of the invention.

[0075] As to amino acid sequences, one of skill will recognize that individual substitutions, deletions or additions to a nucleic acid, peptide, polypeptide, or protein sequence which alters, adds or deletes a single amino acid or a small percentage of amino acids in the encoded sequence is a "conservatively modified variant" where the alteration results in the substitution of an amino acid with a chemically similar amino acid. Conservative substitution tables providing functionally similar amino acids are well known in the art. Such conservatively modified variants are in addition to and do not exclude polymorphic variants, interspecies homologs, and alleles of the invention.

[0076] The following eight groups each contain amino acids that are conservative substitutions for one another:

- 1) Alanine (A), Glycine (G);
- 2) Aspartic acid (D), Glutamic acid (E);
- 3) Asparagine (N), Glutamine (Q);
- 4) Arginine (R), Lysine (K);
- 5) Isoleucine (I), Leucine (L), Methionine (M), Valine (V);
- 6) Phenylalanine (F), Tyrosine (Y), Tryptophan (W);
- 7) Serine (S), Threonine (T); and
- 8) Cysteine (C), Methionine (M)

(see, e.g., Creighton, *Proteins* (1984)).

[0077] Amino acids may be referred to herein by either the common three-letter symbols or by the one-letter symbols recommended by the IUPAC-IUB Biochemical Nomenclature Commission. Nucleotides, likewise, may be referred to by their commonly accepted single-letter codes.

[0078] The term “mutating” or “mutation,” as used in the context of altering the structure or enzymatic activity of a wild-type enzyme, refers to the deletion, insertion, or substitution of any nucleotide or amino acid residue, by chemical, enzymatic, or any other means, in a polynucleotide sequence encoding a that enzyme or the amino acid sequence of a wild-type enzyme, respectively, such that the amino acid sequence of the resulting enzyme is altered at one or more amino acid residues. The site for such an activity-altering mutation may be located anywhere in the enzyme, but is preferably within the active site of the enzyme.

[0079] “Peptide” refers to a polymer in which the monomers are amino acids and are joined together through amide bonds, alternatively referred to as a polypeptide. Additionally, unnatural amino acids, for example,  $\beta$ -alanine, phenylglycine and homoarginine are also included. Amino acids that are not gene-encoded may also be used in the present invention. Furthermore, amino acids that have been modified to include reactive groups, glycosylation sites, polymers, therapeutic moieties, biomolecules and the like may also be used in the invention. All of the amino acids used in the present invention may be either the D - or L - isomer. The L -isomer is generally preferred. In addition, other peptidomimetics are also useful in the present invention. As used herein, “peptide” refers to both glycosylated and unglycosylated peptides. Also included are peptides that are incompletely glycosylated by a system that expresses the peptide. For a general review, see, Spatola, A. F., in CHEMISTRY AND BIOCHEMISTRY OF AMINO ACIDS, PEPTIDES AND PROTEINS, B. Weinstein, eds., Marcel Dekker, New York, p. 267 (1983).

[0080] The term “peptide conjugate,” refers to species of the invention in which a peptide is conjugated with an acyl-containing group that is attached to the peptide through a sugar residue.

[0081] The term “sialic acid” refers to any member of a family of nine-carbon carboxylated sugars. The most common member of the sialic acid family is N-acetyl-neuraminic acid (2-keto-5-acetamido-3,5-dideoxy-D-glycero-D-galactononulopyranos-1-onic acid (often

abbreviated as Neu5Ac, NeuAc, or NANA). A second member of the family is N-glycolyl-neuraminic acid (Neu5Gc or NeuGc), in which the N-acetyl group of NeuAc is hydroxylated. A third sialic acid family member is 2-keto-3-deoxy-nonulosonic acid (KDN) (Nadano *et al.* (1986) *J. Biol. Chem.* **261**: 11550-11557; Kanamori *et al.*, *J. Biol. Chem.* **265**: 21811-21819 (1990)). Also included are 9-substituted sialic acids such as a 9-O-C<sub>1</sub>-C<sub>6</sub> acyl-Neu5Ac like 9-O-lactyl-Neu5Ac or 9-O-acetyl-Neu5Ac, 9-deoxy-9-fluoro-Neu5Ac and 9-azido-9-deoxy-Neu5Ac. For review of the sialic acid family, *see, e.g.*, Varki, *Glycobiology* **2**: 25-40 (1992); *Sialic Acids: Chemistry, Metabolism and Function*, R. Schauer, Ed. (Springer-Verlag, New York (1992)). The synthesis and use of sialic acid compounds in a sialylation procedure is disclosed in international application WO 92/16640, published October 1, 1992.

**[0082]** As used herein, the term “modified saccharyl fragment,” refers to a fragment of a naturally- or non-naturally-occurring carbohydrate that has been modified, typically oxidatively to create a locus for attaching a modifying group. In an exemplary embodiment, the saccharyl fragment is a sialic acid fragment in which the side chain is altered by oxidative degradation. The oxidation produces a carbonyl moiety that is subsequently reductively aminated with an amine analogue of the modifying group. In another exemplary embodiment, the ring structure of the saccharide is linearized by reductive conversion to an alditol (e.g., mannose to mannitol) and derivatized, e.g., at one or more of the primary hydroxyl moieties. Useful, modifying groups include, but are not limited to, water-soluble polymers, water-insoluble polymers, therapeutic moieties, diagnostic moieties, biomolecules and the like.

**[0083]** The term “water-soluble” refers to moieties that have a detectable degree of solubility in water. Methods to detect and/or quantify water solubility are well known in the art. Exemplary water-soluble polymers include peptides, saccharides, poly(ethers), poly(amines), poly(carboxylic acids) and the like. Peptides can have mixed sequences of be composed of a single amino acid, e.g., poly(lysine), poly(aspartic acid), and poly(glutamic acid). An exemplary polysaccharide is poly(sialic acid). An exemplary poly(ether) is poly(ethylene glycol), e.g., m-PEG. Poly(ethylene imine) is an exemplary polyamine, and poly(acrylic) acid is a representative poly(carboxylic acid).

**[0084]** The polymer backbone of the water-soluble polymer can be poly(ethylene glycol) (PEG), e.g., m-PEG. However, it should be understood that other related polymers are also suitable for use in the practice of this invention and that the use of the term PEG or



poly(ethylene glycol) is intended to be inclusive and not exclusive in this respect. The term PEG includes poly(ethylene glycol) in any of its forms, including alkoxy PEG, alkyl PEG (e.g., mPEG), difunctional PEG, multiarmed PEG, forked PEG, branched PEG, pendent PEG (i.e. PEG or related polymers having one or more functional groups pendent to the polymer backbone), or PEG with degradable linkages therein.

[0085] The polymer backbone can be linear or branched. Branched polymer backbones are generally known in the art. Typically, a branched polymer has a central branch core moiety and a plurality of linear polymer chains linked to the central branch core. PEG is commonly used in branched forms that can be prepared by addition of ethylene oxide to various polyols, such as glycerol, pentaerythritol and sorbitol. The central branch moiety can also be derived from several amino acids, such as lysine. The branched poly(ethylene glycol) can be represented in general form as  $R(-\text{PEG}-\text{OH})_m$  in which R represents the core moiety, such as glycerol, pentaerythritol, amino acid (e.g., cysteine, serine, di-lysine, tri-lysine, etc.) and  $m$  represents the number of arms. Multi-armed PEG molecules, such as those described in U.S. Pat. No.s 5,932,462; 5,643,575; European Patent Application 0473,084 A2; WO 96/41813 (and its priority documents), can also be used as the polymer backbone.

[0086] Many other polymers are also suitable for the invention. Polymer backbones that are non-peptidic and water-soluble, with from 2 to about 300 termini, are particularly useful in the invention. Examples of suitable polymers include, but are not limited to, other poly(alkylene glycols), such as poly(propylene glycol) ("PPG"), copolymers of ethylene glycol and propylene glycol and the like, poly(oxyethylated polyol), poly(olefinic alcohol), poly(vinylpyrrolidone), poly(hydroxypropylmethacrylamide), poly( $\alpha$ -hydroxy acid), poly(vinyl alcohol), polyphosphazene, polyoxazoline, poly(N-acryloylmorpholine), such as described in U.S. Pat. No. 5,629,384, which is incorporated by reference herein in its entirety, and copolymers, terpolymers, and mixtures thereof. Although the molecular weight of each chain of the polymer backbone can vary, it is typically in the range of from about 100 Da to about 100,000 Da, often from about 6,000 Da to about 80,000 Da.

[0087] The terms "large-scale" and "industrial-scale" are used interchangeably and refer to a reaction cycle that produces at least about 250 mg, preferably at least about 500 mg, and more preferably at least about 1 gram of glycoconjugate at the completion of a single reaction cycle.

[0088] The term, “glycosyl linking group,” as used herein refers to a glycosyl residue that is a fragment of a parent saccharide, generally prepared by oxidation of one or more primary or secondary hydroxyl moieties on the parent saccharide. An exemplary glycosyl linking group is set forth in Formula I, below. As shown in Formula I, the glycosyl linking group covalently joins the modifying group (e.g., PEG moiety, therapeutic moiety, biomolecule) to the molecule to which it is attached. In the methods of the invention, the “glycosyl linking group” is formed by the covalent modification, via an enzymatic glycosylation reaction linking the agent to an amino acid and/or glycosyl residue on the peptide. The glycosyl linking group can be a saccharide-derived structure that is degraded or degraded and modified prior to the addition of the modifying group (e.g., oxidation→Schiff base formation→reduction). Alternatively, a portion of the glycosyl linking group may be intact. For example, when the glycosyl linking group is Gal-SA\* (SA\* is the saccharyl fragment), with Gal attached to a peptide or lipid, the Gal can be intact. The glycosyl linking groups of the invention may be derived from a saccharide by addition of glycosyl unit(s) or removal of one or more glycosyl unit from a parent saccharide structure, followed by coupling a saccharyl fragment of the invention to the newly placed or exposed glycosyl residue.

[0089] The term “targeting moiety,” as used herein, refers to species that selectively localize in a particular tissue or region of the body. The localization is mediated by specific recognition of molecular determinants, molecular size of the targeting agent or conjugate, ionic interactions, hydrophobic interactions and the like. Other mechanisms of targeting an agent to a particular tissue or region are known to those of skill in the art. Exemplary targeting moieties include antibodies, antibody fragments, transferrin, HS-glycoprotein, coagulation factors, serum proteins,  $\beta$ -glycoprotein, G-CSF, GM-CSF, M-CSF, EPO and the like.

[0090] As used herein, “therapeutic moiety” means any agent useful for therapy including, but not limited to, antibiotics, anti-inflammatory agents, anti-tumor drugs, cytotoxins, and radioactive agents. “Therapeutic moiety” includes prodrugs of bioactive agents, constructs in which more than one therapeutic moiety is bound to a carrier, e.g., multivalent agents. Therapeutic moiety also includes proteins and constructs that include proteins. Exemplary proteins include, but are not limited to, Erythropoietin (EPO), Granulocyte Colony Stimulating Factor (G-CSF), Granulocyte Macrophage Colony Stimulating Factor (GM-CSF), Interferon (e.g., Interferon- $\alpha$ , - $\beta$ , - $\gamma$ ), Interleukin (e.g., Interleukin II), serum proteins (e.g.,

Factors VII, VIIa, VIII, IX, and X), Human Chorionic Gonadotropin (HCG), Follicle Stimulating Hormone (FSH) and Lutenizing Hormone (LH) and antibody fusion proteins (e.g. Tumor Necrosis Factor Receptor ((TNFR)/Fc domain fusion protein)).

**[0091]** As used herein, "anti-tumor drug" means any agent useful to combat cancer

including, but not limited to, cytotoxins and agents such as antimetabolites, alkylating agents, anthracyclines, antibiotics, antimitotic agents, procarbazine, hydroxyurea, asparaginase, corticosteroids, interferons and radioactive agents. Also encompassed within the scope of the term "anti-tumor drug," are conjugates of peptides with anti-tumor activity, *e.g.* TNF- $\alpha$ .

Conjugates include, but are not limited to those formed between a therapeutic protein and a glycoprotein of the invention. A representative conjugate is that formed between PSGL-1 and TNF- $\alpha$ .

**[0092]** As used herein, "a cytotoxin or cytotoxic agent" means any agent that is detrimental to cells. Examples include taxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin, etoposide, tenoposide, vincristine, vinblastine, colchicin, doxorubicin,

daunorubicin, dihydroxy anthracenedione, mitoxantrone, mithramycin, actinomycin D, 1-dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, and puromycin and analogs or homologs thereof. Other toxins include, for example, ricin, CC-1065 and analogues, the duocarmycins. Still other toxins include diphtheria toxin, and snake venom (*e.g.*, cobra venom).

**[0093]** As used herein, "a radioactive agent" includes any radioisotope that is effective in diagnosing or destroying a tumor. Examples include, but are not limited to, indium-111, cobalt-60. Additionally, naturally occurring radioactive elements such as uranium, radium, and thorium, which typically represent mixtures of radioisotopes, are suitable examples of a radioactive agent. The metal ions are typically chelated with an organic chelating moiety.

**[0094]** Many useful chelating groups, crown ethers, cryptands and the like are known in the art and can be incorporated into the compounds of the invention (*e.g.*, EDTA, DTPA, DOTA, NTA, HDTA, *etc.* and their phosphonate analogs such as DTPP, EDTP, HDTP, NTP, *etc.*).

*See, for example, Pitt et al., "The Design of Chelating Agents for the Treatment of Iron Overload," In, INORGANIC CHEMISTRY IN BIOLOGY AND MEDICINE; Martell, Ed.; American Chemical Society, Washington, D.C., 1980, pp. 279-312; Lindoy, THE CHEMISTRY OF MACROCYCLIC LIGAND COMPLEXES; Cambridge University Press, Cambridge, 1989; Dugas,*

BIOORGANIC CHEMISTRY; Springer-Verlag, New York, 1989, and references contained therein.

[0095] Additionally, a manifold of routes allowing the attachment of chelating agents, crown ethers and cyclodextrins to other molecules is available to those of skill in the art. *See*,  
5 for example, Meares *et al.*, "Properties of In Vivo Chelate-Tagged Proteins and Polypeptides." In, MODIFICATION OF PROTEINS: FOOD, NUTRITIONAL, AND PHARMACOLOGICAL ASPECTS;" Feeney, *et al.*, Eds., American Chemical Society, Washington, D.C., 1982, pp. 370-387; Kasina *et al.*, *Bioconjugate Chem.*, **9**: 108-117 (1998); Song *et al.*, *Bioconjugate Chem.*, **8**: 249-255 (1997).

10 [0096] As used herein, "pharmaceutically acceptable carrier" includes any material, which when combined with the conjugate retains the conjugates' activity and is non-reactive with the subject's immune systems. Examples include, but are not limited to, any of the standard pharmaceutical carriers such as a phosphate buffered saline solution, water, emulsions such as oil/water emulsion, and various types of wetting agents. Other carriers may also include  
15 sterile solutions, tablets including coated tablets and capsules. Typically such carriers contain excipients such as starch, milk, sugar, certain types of clay, gelatin, stearic acid or salts thereof, magnesium or calcium stearate, talc, vegetable fats or oils, gums, glycols, or other known excipients. Such carriers may also include flavor and color additives or other ingredients. Compositions comprising such carriers are formulated by well known  
20 conventional methods.

[0097] As used herein, "administering" means oral administration, administration as a suppository, topical contact, intravenous, intraperitoneal, intramuscular, intralesional, or subcutaneous administration, administration by inhalation, or the implantation of a slow-release device, *e.g.*, a mini-osmotic pump, to the subject. Adminsitration is by any route  
25 including parenteral and transmucosal (*e.g.*, oral, nasal, vaginal, rectal, or transdermal), particularly by inhalation. Parenteral administration includes, *e.g.*, intravenous, intramuscular, intra-arteriole, intradermal, subcutaneous, intraperitoneal, intraventricular, and intracranial. Moreover, where injection is to treat a tumor, *e.g.*, induce apoptosis, administration may be directly to the tumor and/or into tissues surrounding the tumor. Other  
30 modes of delivery include, but are not limited to, the use of liposomal formulations, intravenous infusion, transdermal patches, etc.

[0098] The term “isolated” refers to a material that is substantially or essentially free from components, which are used to produce the material. For conjugates of the invention, the term “isolated” refers to material that is substantially or essentially free from components, which normally accompany the material in the mixture used to prepare the conjugate.

5 “Isolated” and “pure” are used interchangeably. Typically, isolated conjugates of the invention have a level of purity preferably expressed as a range. The lower end of the range of purity for the conjugates is about 60%, about 70% or about 80% and the upper end of the range of purity is about 70%, about 80%, about 90% or more than about 90%.

[0099] When the conjugates are more than about 90% pure, their purities are also  
10 preferably expressed as a range. The lower end of the range of purity is about 90%, about 92%, about 94%, about 96% or about 98%. The upper end of the range of purity is about 92%, about 94%, about 96%, about 98% or about 100% purity.

[0100] Purity is determined by any art-recognized method of analysis (*e.g.*, band intensity on a silver stained gel, polyacrylamide gel electrophoresis, HPLC, or a similar means).

15 [0101] “Essentially each member of the population,” as used herein, describes a characteristic of a population of peptide conjugates of the invention in which a selected percentage of the modified saccharyl fragments added to a peptide are added to multiple, identical acceptor sites on the peptide. “Essentially each member of the population” speaks to the “homogeneity” of the sites on the peptide conjugated to a modified saccharyl fragment  
20 and refers to conjugates of the invention, which are at least about 80%, preferably at least about 90% and more preferably at least about 95% homogenous.

[0102] “Homogeneity,” refers to the structural consistency across a population of acceptor moieties to which the modified saccharyl fragments are conjugated. Thus, in a peptide conjugate of the invention in which each modified saccharyl fragment moiety is conjugated  
25 to a site having the same structure as the site to which every other modified saccharyl fragment is conjugated, the peptide conjugate is said to be about 100% homogeneous. Homogeneity is typically expressed as a range. The lower end of the range of homogeneity for the peptide conjugates is about 60%, about 70% or about 80% and the upper end of the range of purity is about 70%, about 80%, about 90% or more than about 90%.

30 [0103] When the peptide conjugates are more than or equal to about 90% homogeneous, their homogeneity is also preferably expressed as a range. The lower end of the range of

homogeneity is about 90%, about 92%, about 94%, about 96% or about 98%. The upper end of the range of purity is about 92%, about 94%, about 96%, about 98% or about 100% homogeneity. The purity of the peptide conjugates is typically determined by one or more methods known to those of skill in the art, e.g., liquid chromatography-mass spectrometry (LC-MS), matrix assisted laser desorption mass time of flight spectrometry (MALDITOF),  
5 capillary electrophoresis, and the like.

[0104] “Substantially uniform conjugate” or a “substantially uniform conjugation pattern,” when referring to a glycoconjugate species, refers to the percentage of peptide glycosylation sites that are functionalized directly, or through a glycosyl linker, with a modified saccharyl  
10 fragment. A substantially uniform conjugation pattern exists if substantially all (as defined below) members of a glycosylation site population intended to bear the modified saccharyl fragment are directly or indirectly functionalized with that fragment.

[0105] The term “substantially” in the above definitions of “substantially uniform” generally means at least about 40%, at least about 70%, at least about 80%, or more  
15 preferably at least about 90%, and still more preferably at least about 95% of the acceptor moieties for a particular modified saccharyl fragment are modified by that fragment.

[0106] The terms “(glyco)peptide” and “(glyco)lipid,” refer, respectively, to peptide and glycopeptide; and lipid and glycolipid. The terms “peptide” and “lipid” are used generically to refer to both glycosylated and non-glycosylated analogues of these species.

## 20 **Introduction**

[0107] The present invention provides conjugates bearing one or more modified saccharyl fragment moiety. The modified fragment is attached to an acceptor moiety on a substrate, e.g., an amino acid or glycosyl residue of a peptide or glycopeptide, or onto an aglycone or glycosyl residue of a glycolipid (e.g., sphingosine, ceramide, etc.). Also provided are  
25 enzymatically-mediated methods for producing the conjugates of the invention, and activated modified saccharyl fragments of use in the methods. The invention also provides pharmaceutical formulations that include a conjugate formed by a method of the invention.

[0108] Conjugates of the invention are formed between a therapeutic core molecule, e.g., (glyco)peptide, (glyco)lipid, and diverse modifying groups such as water-soluble polymers, therapeutic moieties, diagnostic moieties, targeting moieties and the like. The modifying  
30 group is conjugated to the therapeutic species through a saccharyl fragment. Also provided

are conjugates that include two or more peptides linked together through a linker arm, *i.e.*, multifunctional conjugates. The multi-functional conjugates of the invention can include two or more copies of the same peptide or a collection of diverse peptides with different structures and/or properties. In exemplary conjugates according to this embodiment, the linker between the two peptides includes at least one saccharyl fragment, or modified saccharyl fragment as described herein.

[0109] The conjugates of the invention are prepared by the enzymatic conjugation of an activated modified saccharyl fragment to a therapeutic substrate. When the conjugate of the invention is a glycopeptide conjugate, the modified saccharyl fragment is attached directly to an amino acid of a glycosylation site, or to a glycosyl residue attached either directly or indirectly (e.g., through one or more glycosyl residue) to a glycosylation site.

[0110] The invention also provides lipid conjugates in which the modified saccharyl fragment is attached to an aglycone moiety of a lipid or to a glycosyl residue of a glycolipid.

[0111] The modified saccharyl fragment, when interposed between the peptide (or glycosyl residue) and the modifying group, becomes what is referred to herein as a “glycosyl linking group.” Using the exquisite selectivity of enzymes, such as glycosyl transferases, amidases, endoglycanases, endoglycoceramidases, and the like, the present method provides peptides and lipids that bear a desired group at one or more specific locations. Thus, in exemplary conjugates according to the present invention, a modified saccharyl fragment is attached directly to a selected locus on the peptide chain or, alternatively, the modified saccharyl fragment is appended onto a carbohydrate moiety of a glycopeptide. Peptides in which modified saccharyl fragments are bound to both a glycopeptide carbohydrate and directly to an amino acid residue of the peptide backbone are also within the scope of the present invention.

[0112] The methods of the invention make it possible to assemble modified glycopeptides and glycolipids that have a substantially homogeneous derivatization pattern; the enzymes used in the invention are generally selective for a particular glycosyl residue or for particular substituents, or substituent patterns, on a glycosyl residue. The methods are also practical for large-scale production of modified glycopeptide and glycolipid conjugates. In one embodiment the methods of the invention provide a practical means for large-scale preparation of glycopeptide and glycolipid conjugates having preselected uniform derivatization patterns. The methods are particularly well suited for modification of

therapeutic peptides, including but not limited to, glycopeptides that are incompletely glycosylated during production in cell culture cells (*e.g.*, mammalian cells, insect cells, plant cells, fungal cells, yeast cells, or prokaryotic cells) or transgenic plants or animals.

[0113] The methods of the invention also provide conjugates of glycosylated and unglycosylated peptides, and glycolipids, with increased therapeutic half-life due to, for example, reduced clearance rate, or reduced rate of uptake by the immune or reticuloendothelial system (RES). Moreover, the methods of the invention provide a means for masking antigenic determinants on peptides, thus reducing or eliminating a host immune response against the peptide. Selective attachment of targeting agents to a peptide or glycolipid using an appropriate modified saccharyl fragment can also be used to target the peptide or glycolipid to a particular tissue or cell surface receptor that is specific for the particular targeting agent. Moreover, there is provided a class of peptides and glycolipids that are specifically modified with a therapeutic moiety conjugated through a glycosyl linking group.

## **The Embodiments**

### **Compositions: Glyco-conjugates**

[0114] The present invention provides glyco-conjugates that include a saccharyl fragment functionalized with a modifying group. When the saccharyl fragment is formed by oxidation of a saccharide, *e.g.*, sialic acid, the reagent used to conjugate the modifying group to the oxidized saccharide fragment generally includes a group that reacts with a carbonyl moiety formed during the oxidation.

### ***Modified saccharyl fragments***

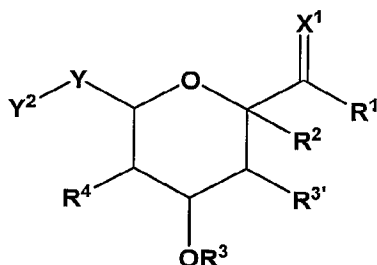
[0115] The present invention provides compounds and methods that are based upon the discovery that enzymes capable of transferring an intact glycosyl moiety to an acceptor substrate are also capable of transferring a modified saccharyl fragment to the acceptor. Accordingly, the invention is not limited by the structure or methods of obtaining appropriate saccharyl fragments or modified saccharyl fragments.

[0116] In an exemplary embodiment, the saccharide fragment is prepared by the oxidative degradation of the parent saccharide. Methods of selectively oxidizing saccharide groups are well known in the art. For example, the periodate ion is of use to cleave vicinal diols, forming the corresponding dialdehyde. Controlled periodate oxidation of the side chain of



sialic acid leads to the formation of an oxidized or oxidized and truncated side chain bearing an aldehyde. By choosing appropriate conditions, a side chain containing from one to three carbon atoms is produced. See, for example, Chai et al., *Carbohydr. Res.* **239**: 107-115 (1993); and Murray et al., *Carbohydr. Res.* **186**: 107-115 (1989).

- 5 [0117] The carbonyl moiety introduced into the saccharyl fragment undergoes those reactions generally used for the modification of a carbonyl moiety. For example, modifying groups that include amines are of use as are those that form imines, e.g., hydrazines, semicarbazines and the like. Other typical reactions include the reaction of the carbonyl moiety with ylides (e.g., sulfur and phosphorus), and with Grignard and lithium reagents.
- 10 [0118] An exemplary modified saccharyl fragment of the invention is formed by the oxidative degradation of the side chain of sialic acid. The oxidation leads to the formation of a carbonyl moiety that is reductively aminated with an amine derivative of a modifying group of interest. Thus, in this embodiment, the invention provides a modified saccharyl fragment having a structure according to Formula I:



(I).

15

- [0119] In Formula I, the symbol  $X^1$  represents O or  $NR^8$ .  $R^8$  is a member selected from H, OH, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl. Appropriate  $R^1$  groups are selected from  $OR^9$ ,  $NR^9R^{10}$ , substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl. The symbols  $R^9$  and  $R^{10}$  independently represent H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, and  $C(O)R^{11}$ .  $R^{11}$  is a group such as substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl and substituted or unsubstituted heterocycloalkyl.
- 20

- [0120] The symbol  $R^2$  is a member selected from an amino acid residue of a peptide, a carbohydrate moiety attached to an amino acid residue of a peptide, or a carbohydrate moiety attached to an amino acid residue of a peptide through a linker. Exemplary linkers include one or more additional carbohydrate moieties in addition to that of  $R^2$ .  $R^3$  is a member
- 25

selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl.  $R^{3'}$  is a member selected from H,  $OR^{4'}$ , substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl.  $R^4$  and  $R^{4'}$  are members independently selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, OH and NHC(O) $R^{12}$ .  $R^{12}$  is selected from substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, substituted or unsubstituted heterocycloalkyl and  $NR^{13}R^{14}$ , in which  $R^{13}$  and  $R^{14}$  are members independently selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl. In an exemplary embodiment,  $R^{3'}$  is H.

**[0121]** Y is the residue of the sialic acid side chain remaining following oxidation and further chemical modification. Exemplary groups for Y include  $CH_2$ ,  $CH(OH)CH_2$ ,  $CH(OH)CH(OH)CH_2$  when the oxidation leads to formation of an aldehyde that is subsequently reductively aminated. When the aldehyde is converted to an imine species, or when the product results from addition of a phosphorus or sulfur ylide, Y is typically CH,  $CH(OH)CH$  or  $CH(OH)CH(OH)CH$ . When the aldehyde is reacted with a Grignard or lithium reagent, exemplary Y groups include  $CH(OH)$ ,  $CH(OH)CH(OH)$ ,  $CH(OH)CH(OH)CH(OH)$  or an elimination product thereof, e.g., dehydration product.

**[0122]** The symbol  $Y^2$  represents groups formed by addition to the carbonyl moiety of the fragment.  $Y^2$  includes at least one modifying group e.g., biomolecule, therapeutic moiety, diagnostic moiety, and a polymeric modifying group, as exemplified by the term  $R^{6a}$ . Exemplary identities for  $Y^2$  include substituted alkyl (e.g., formed by Wittig, Grignard or other appropriate chemistries),  $R^6$  and nitrogen-containing species, e.g.,  $NR^6R^7$  or  $R^6R^7N=N$ .  $R^6$  and  $R^7$  are independently H,  $C(O)R^{6b}$  or  $-L^a-R^{6b}$  wherein  $R^{6b}$  is H or  $R^{6a}$  and  $L^a$  is selected from a bond and a linker group. In an exemplary embodiment,  $Y^2$  is  $N(R^6)-L^a-(m-PEG)_s$  wherein  $L^a$  is a linker moiety which is a member selected from an amino acid residue and a peptidyl residue; and the index s is an integer from 1 to 3.

**[0123]** When  $Y^2$  is substituted or unsubstituted alkyl, e.g., an alkene species formed by a Wittig reaction, or saturated species formed by Grignard or lithium chemistries,  $Y^2$  includes at least one modifying group (water-soluble or -insoluble polymer) as exemplified by the term  $R^{6a}$ .

**[0124]** In an exemplary embodiment, the modified saccharyl fragment is prepared by reacting a carbonyl-containing saccharyl fragment with a Wittig reagent that includes within

its structure a water-soluble polymer, e.g., m-PEG. Wittig reagents of m-PEG are readily formed by reaction of chloro-m-PEG with  $\text{PPh}_3$  and treating the resulting adduct with a base to form the ylide. Other ylides of use in forming the compounds of the invention are prepared by deprotonating an alkyl phosphonate according to the Arbuzov reaction and  
5 reacting the carbonyl moiety of the saccharyl fragment with this ylide under conditions appropriate for the Horner-Emmons reaction.

[0125] Grignard reagents of use in present invention, e.g. m-PEGMgBr, are readily prepared according to art-recognized methods. For example, m-PEG-Br is reacted with Mg under anhydrous conditions.

10 [0126] In another exemplary embodiment, the carbonyl-containing saccharyl fragment is reductively aminated with ammonia. The resulting amine is alkylated or acylated with a selected modifying group, e.g., m-PEG or branched m-PEG.

[0127] Typically, the saccharyl fragment is a monosaccharide; however, because the side chain of sialic acid is selectively oxidized in the presence of the vicinal diols of other  
15 saccharides, the present invention is not limited to the use of modified sialic acid, but is of use with sialic acid fragment-containing oligosaccharides and polysaccharides as well.

[0128] In another aspect, the invention provides an activated modified saccharyl fragment that is of use in the methods of the invention. An exemplary activated modified saccharyl fragment includes an activated leaving group. As used herein, the term "activated leaving  
20 group" refers to those moieties, which are easily displaced in enzyme-regulated nucleophilic substitution reactions. Many activated sugars are known in the art. See, for example, Vocadlo et al., In CARBOHYDRATE CHEMISTRY AND BIOLOGY, Vol. 2, Ernst *et al.* Ed., Wiley-VCH Verlag: Weinheim, Germany, 2000; Kodama *et al.*, *Tetrahedron Lett.* **34**: 6419 (1993); Loughheed, *et al.*, *J. Biol. Chem.* **274**: 37717 (1999)).

25 [0129] In an exemplary embodiment, according to this aspect, the saccharyl fragment has a structure according to Formula I in which  $\text{R}^2$  is an activating group. An exemplary activating group is a nucleotide, forming a nucleotide sugar in which the sugar moiety is the saccharyl fragment.  $\text{R}^2$  can also be a leaving group (activating group), such as a halogen, sulfonate ester and the like.

30 [0130] An exemplary activated leaving group is a nucleotide, which can be utilized to add the modified saccharyl fragment to an acceptor moiety on the substrate. Exemplary sugar

nucleotides present in the compounds of the invention include nucleotide mono-, di- or triphosphates or analogs thereof. In a preferred embodiment, the modified saccharyl fragment nucleotide is selected from a UDP-glycoside, CMP-glycoside, or a GDP-glycoside. Even more preferably, the modified saccharyl fragment nucleotide is selected from analogues of UDP-galactose, UDP-galactosamine, UDP-glucose, UDP-glucosamine, GDP-mannose, GDP-fucose, CMP-sialic acid or CMP-NeuAc in which the saccharyl moiety (other than the nucleotide ribose) is a saccharyl fragment bearing a modifying group.

[0131] In an exemplary embodiment, one or more sugar nucleotides or modified sugar nucleotides are used in conjunction with a glycosyltransferase.

[0132] In other embodiments, the activating moiety is an activated leaving group other than a nucleotide. Examples of non-nucleotide activating groups include fluoro, chloro, bromo, tosylate ester, mesylate ester, triflate ester and the like. Preferred activated leaving groups, for use in the present invention, are those that do not significantly sterically encumber the enzymatic transfer of the glycoside to the acceptor. Accordingly, preferred embodiments of activated glycoside derivatives include glycosyl fluorides and glycosyl mesylates, with glycosyl fluorides being particularly preferred. Among the glycosyl fluorides,  $\alpha$ -galactosyl fluoride,  $\alpha$ -mannosyl fluoride,  $\alpha$ -glucosyl fluoride,  $\alpha$ -fucosyl fluoride,  $\alpha$ -xylosyl fluoride,  $\alpha$ -sialyl fluoride,  $\alpha$ -N-acetylglucosaminyl fluoride,  $\alpha$ -N-acetylgalactosaminyl fluoride,  $\beta$ -galactosyl fluoride,  $\beta$ -mannosyl fluoride,  $\beta$ -glucosyl fluoride,  $\beta$ -fucosyl fluoride,  $\beta$ -xylosyl fluoride,  $\beta$ -sialyl fluoride,  $\beta$ -N-acetylglucosaminyl fluoride and  $\beta$ -N-acetylgalactosaminyl fluoride are most preferred.

[0133] By way of illustration, glycosyl fluorides can be prepared from the saccharyl fragment or modified saccharyl fragment by first acetylating the sugar and then treating it with HF/pyridine. This generates the thermodynamically most stable anomer of the protected (acetylated) glycosyl fluoride (*i.e.*, the  $\alpha$ -glycosyl fluoride). If the less stable anomer (*i.e.*, the  $\beta$ -glycosyl fluoride) is desired, it can be prepared by converting the peracetylated sugar with HBr/HOAc or with HCl to generate the anomeric bromide or chloride. This intermediate is reacted with a fluoride salt such as silver fluoride to generate the glycosyl fluoride. Acetylated glycosyl fluorides may be deprotected by reaction with mild (catalytic) base in methanol (*e.g.* NaOMe/MeOH). In addition, many glycosyl fluorides are commercially available.

[0134] Other activated glycosyl derivatives can be prepared using conventional methods known to those of skill in the art. For example, glycosyl mesylates can be prepared by treatment of the fully benzylated hemiacetal form of the sugar with mesyl chloride, followed by catalytic hydrogenation to remove the benzyl groups.

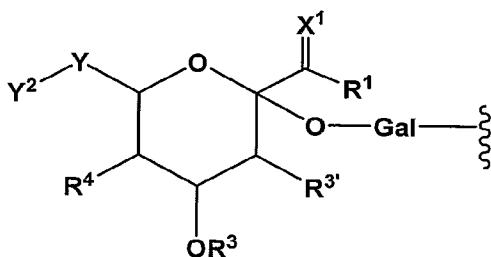
5 [0135] In an exemplary embodiment, one or more activated glycosyl derivative such as those set forth above is used in conjunction with an enzyme that is a mutant of a degradative enzyme; mutated to enhance its activity forming glycosidic and amino-glycosidic bonds relative to the activity of the wild-type, which predominantly cleave these bonds. Enzymes of use in this embodiment include those described in WO03/046150, WO03/045980, and  
10 their US counterpart patent applications).

[0136] In addition to including a moiety according to Formula I, the conjugates of the invention can include one or more additional modified saccharyl fragment appended to an amino acid, aglycone or glycosyl residue of the conjugate. The structure and preparation of  
15 exemplary modified saccharyl fragments that are of use in combination with the modified saccharyl fragment of the invention are also disclosed in WO03/031464 and related U.S. and PCT applications.

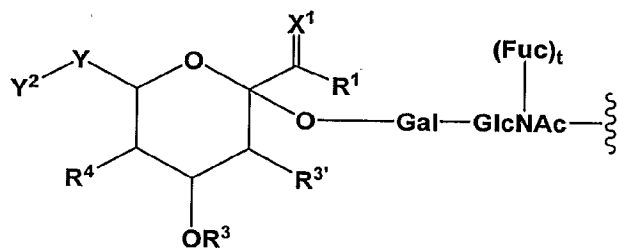
### *Sugars*

[0137] Any sugar can be utilized as the sugar core of the modified saccharyl fragment conjugates of the invention. Exemplary sugar cores that are useful in forming the  
20 compositions of the invention include, but are not limited to, sialic acid, glucose, galactose, and mannose and N-acetyl analogues of these sugars. Also of use are fucose, xylose, ribose, and arabinose. Also encompassed within the invention are species in which the sugar core is a disaccharide, an oligosaccharide or a polysaccharide.

[0138] The invention provides a peptide or lipid conjugate that includes a glycosyl  
25 linking group having the formula:

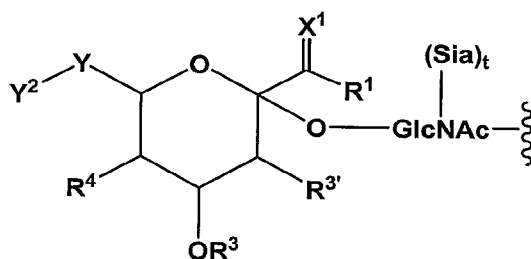


[0139] In other embodiments, the glycosyl linking group has the formula:



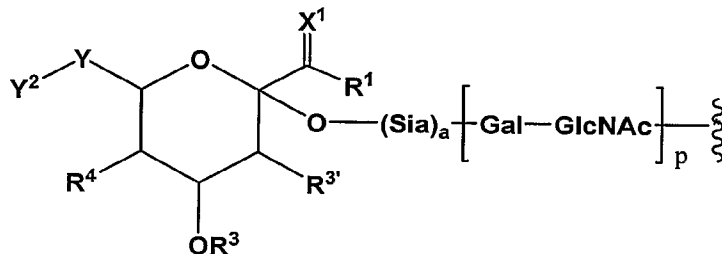
in which the index  $t$  is 0 or 1.

[0140] In a still further exemplary embodiment, the glycosyl linking group has the formula:



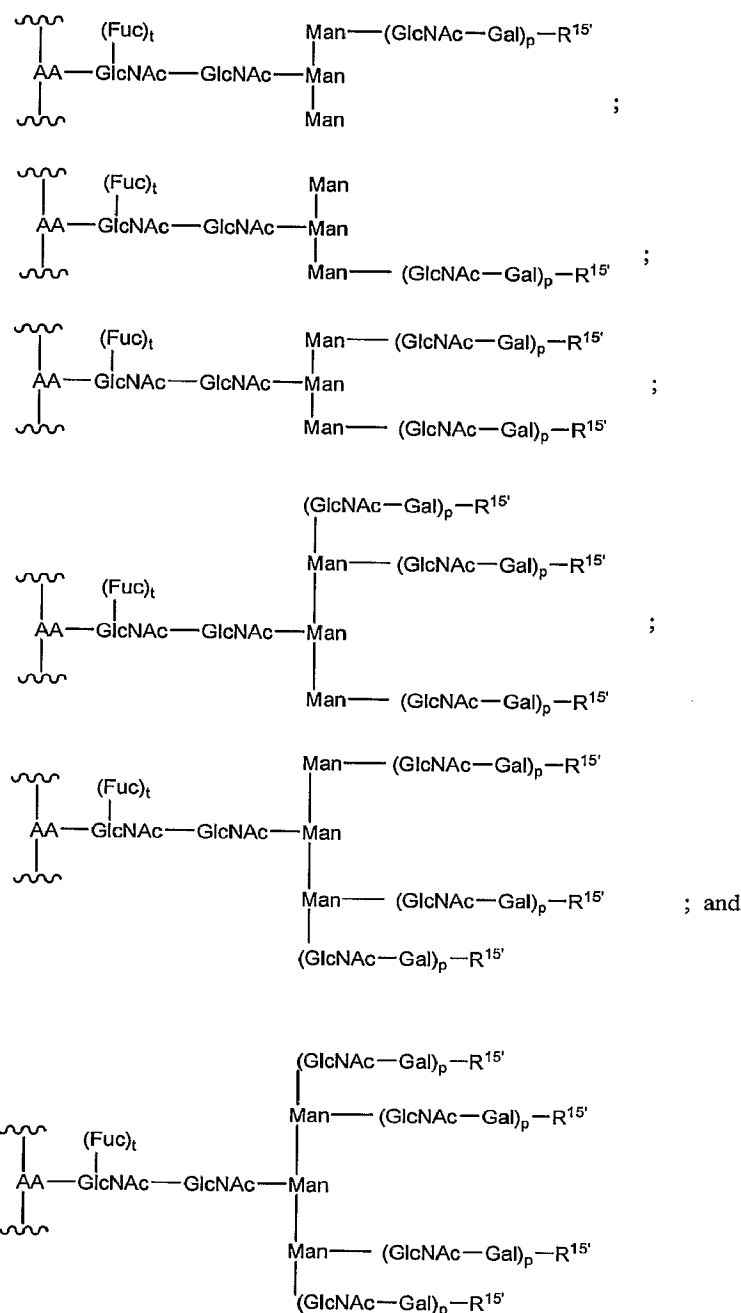
in which the index  $t$  is 0 or 1.

[0141] In yet another embodiment, the glycosyl linking group has the formula:



in which the index  $p$  represents an integer from 1 to 10; and  $a$  is either 0 or 1.

[0142] In an exemplary embodiment, the invention provides a glycoPEGylated peptide conjugate which is selected from the formulae set forth below:



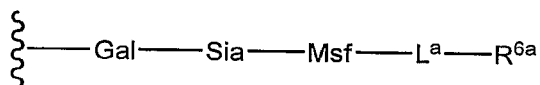
[0143] In the formulae above, the index  $t$  is an integer from 0 to 1 and the index  $p$  is an integer from 1 to 10. The symbol  $\text{R}^{15'}$  represents H, OH (*e.g.*, Gal-OH), a modified saccharyl fragment (Msf), a Msf which comprises  $-\text{L}^a - \text{R}^{6a}$ , a Msf which comprises  $\text{R}^{6a}$ , wherein  $\text{R}^{6a}$  is a

5 polymeric modifying group, or a sialyl moiety to which is bound a modified saccharyl fragment which comprises  $-\text{L}^a - \text{R}^{6a}$  (*e.g.*, Sia-Msf- $\text{L}^a - \text{R}^{6a}$ ), or a sialyl moiety to which is bound a modified saccharyl fragment which comprises  $\text{R}^{6a}$ , (*e.g.*, Sia-Msf- $\text{R}^{6a}$ ) (“Sia-Msf<sup>p</sup>”).

Exemplary polymer modified saccharyl moieties have a structure according to Formula I. An

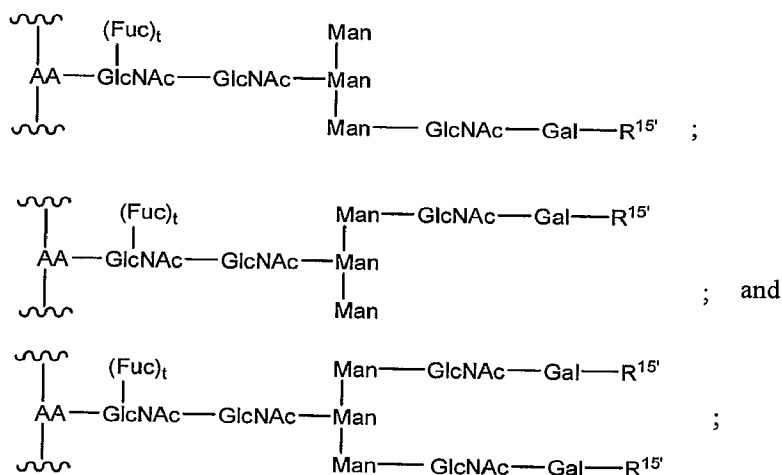
exemplary peptide conjugate of the invention will include at least one glycan having a  $R^{15'}$  that includes a structure according to Formula I. In a further exemplary embodiment, the oxygen is attached to the carbon at position 3 of a galactose residue. In an exemplary embodiment, the modified sialic acid is linked  $\alpha 2,3$ -to the galactose residue. In another exemplary embodiment, the sialic acid is linked  $\alpha 2,6$ -to the galactose residue.

[0144] In an exemplary embodiment,  $R^{15'}$  is a sialyl moiety to which is bound a modified saccharyl fragment which comprises  $-L^a-R^{6a}$ , or  $R^{6a}$ , (*e.g.*, Sia-Msf- $L^a-R^{6a}$ ) (“Sia-Msf<sup>p</sup>”). Here, the glycosyl linking group is linked to a galactosyl moiety through a sialyl moiety:



10 An exemplary species according to this motif is prepared by conjugating Msf- $L^a-R^{6a}$  to a terminal sialic acid of a glycan using an enzyme that forms Sia-Sia bonds, *e.g.*, CST-II, ST8Sia-II, ST8Sia-III and ST8Sia-IV.

[0145] In another exemplary embodiment, the glycans on the peptide conjugates have a formula that is selected from the group:

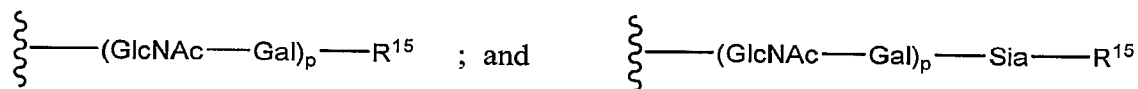


15 and combinations thereof.

[0146] In each of the formulae above,  $R^{15'}$  is as discussed above. Moreover, an exemplary peptide conjugate of the invention will include at least one glycan with an  $R^{15'}$  moiety having a structure according to Formula.

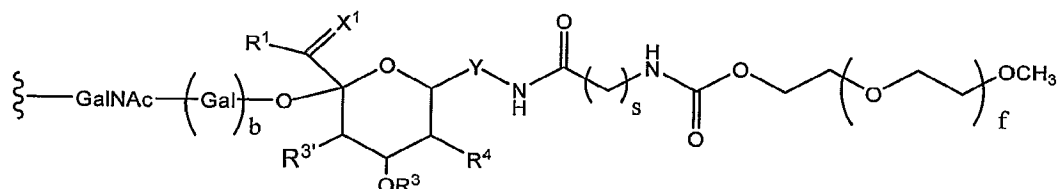


[0147] In another exemplary embodiment, the glycosyl linking group has a formula according to:



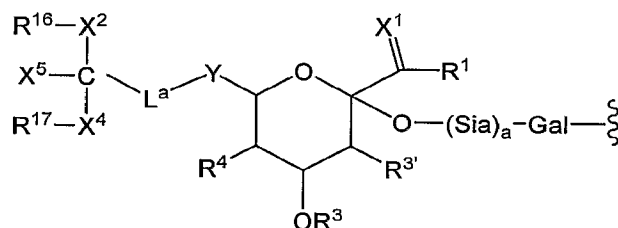
wherein  $\text{R}^{15}$  includes a modified saccharyl fragment; and the index  $p$  is an integer selected from 1 to 10.

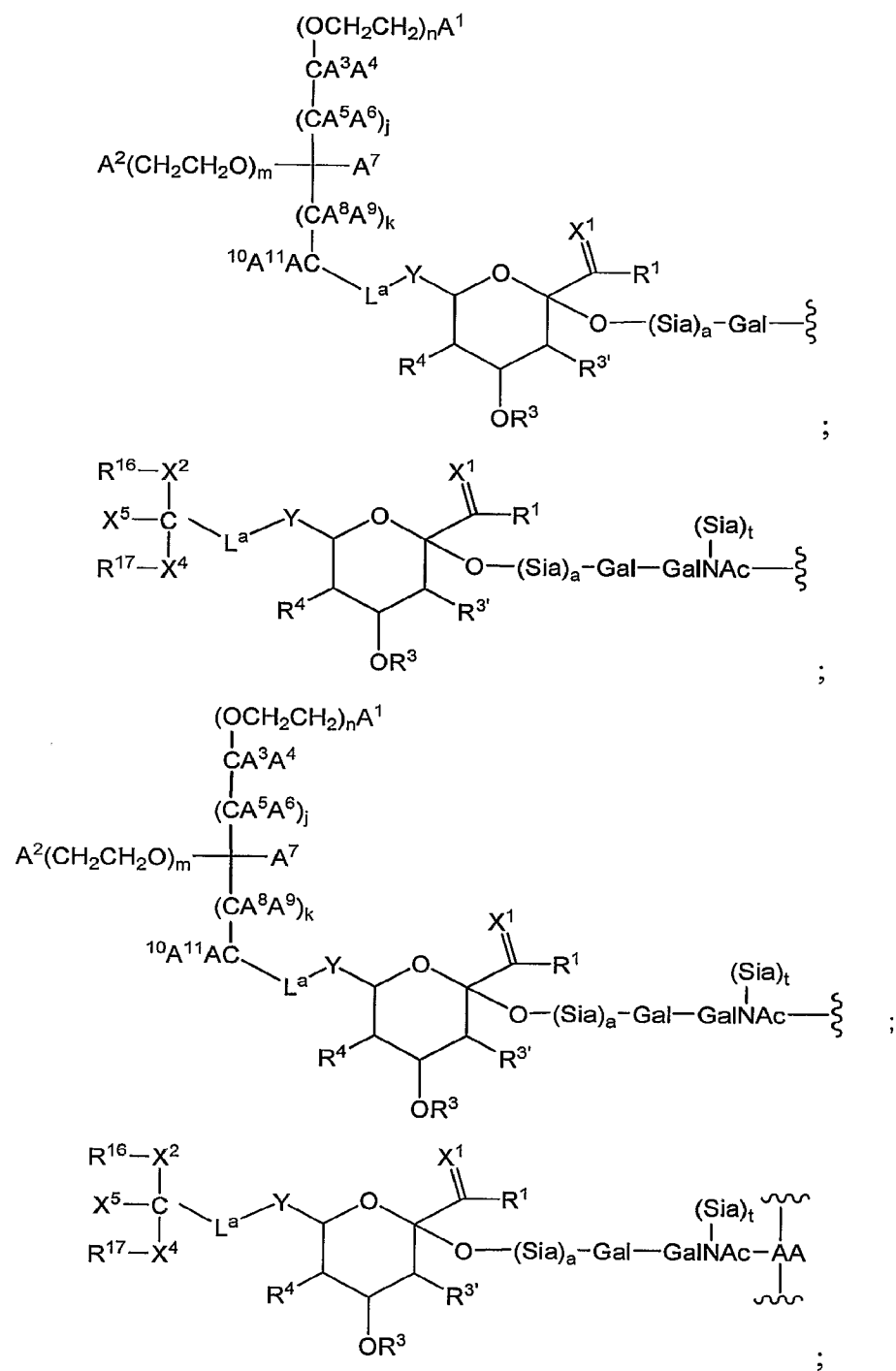
[0148] In an exemplary embodiment, the modified saccharyl fragment has the formula:

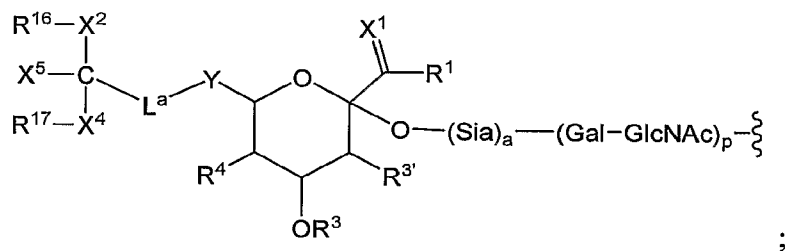
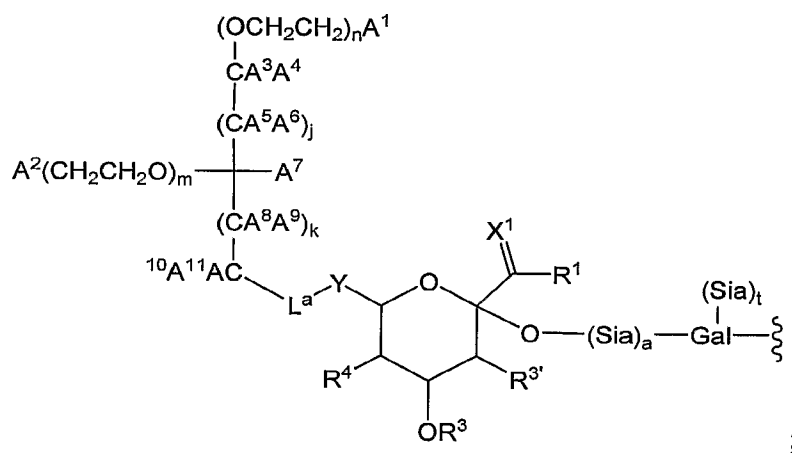
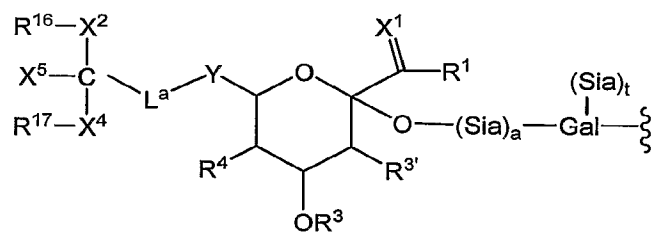
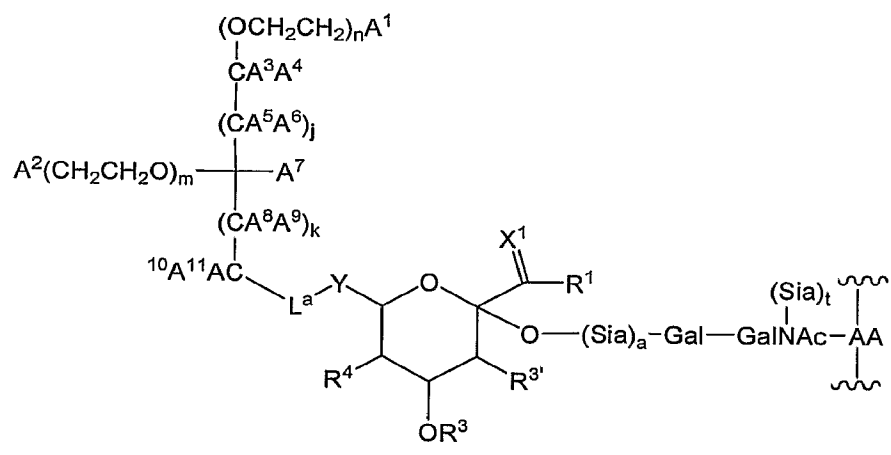


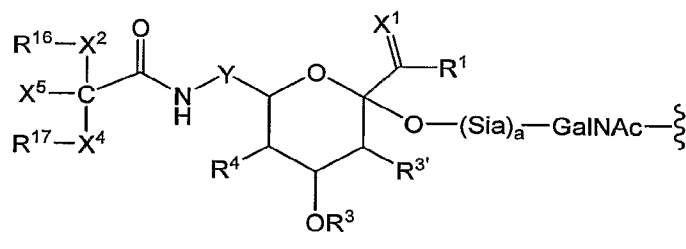
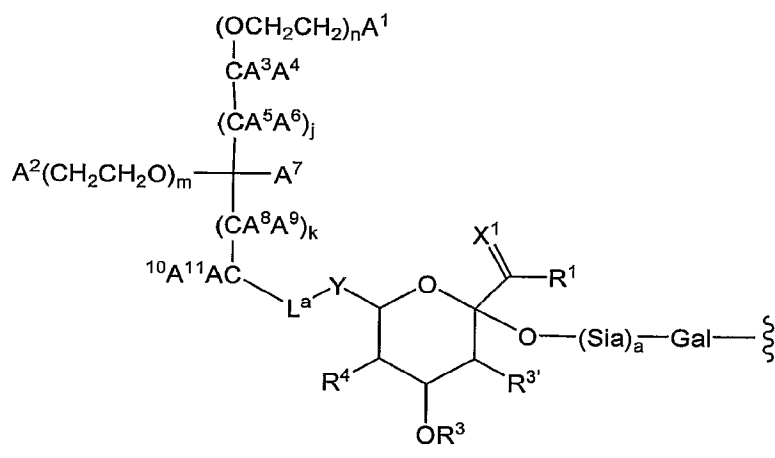
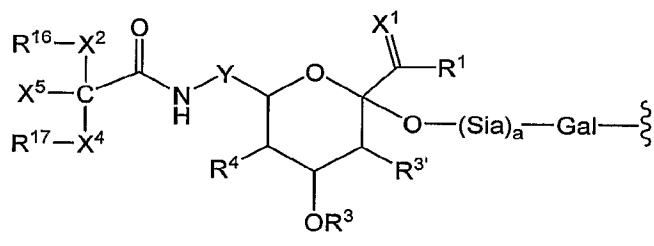
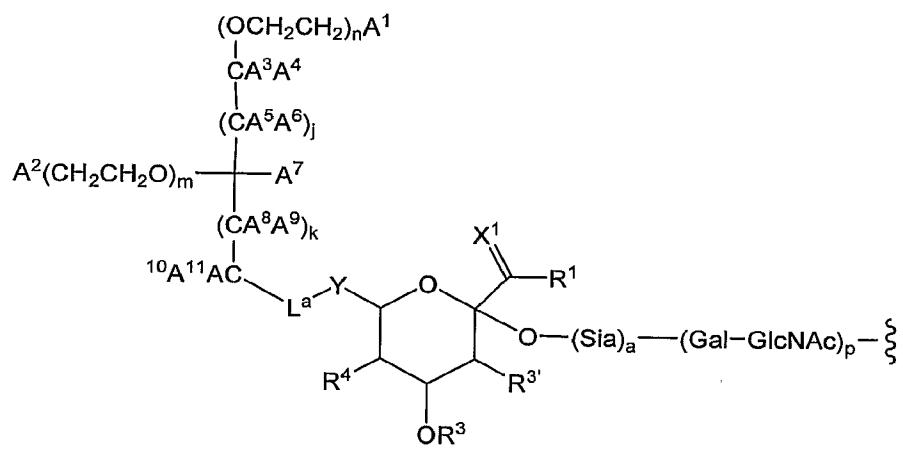
in which  $b$  is an integer from 0 to 1. The index  $s$  represents an integer from 1 to 10; and the index  $f$  represents an integer from 1 to 2500.

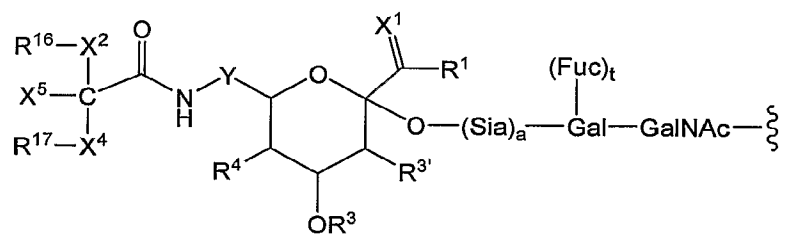
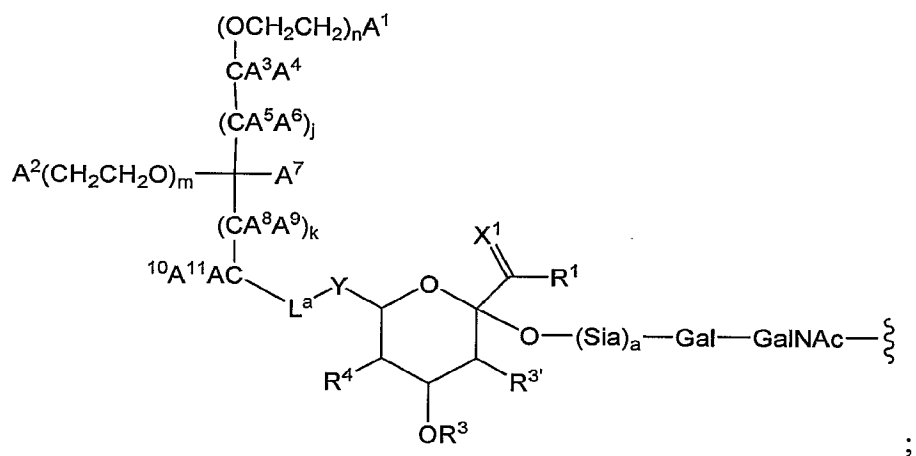
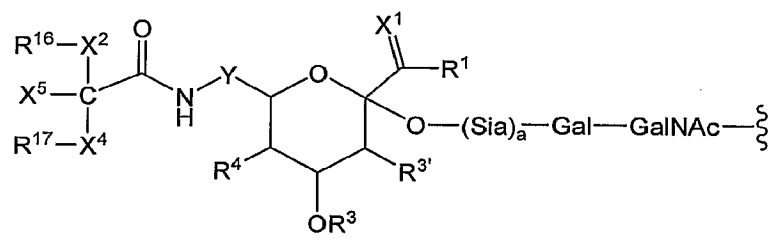
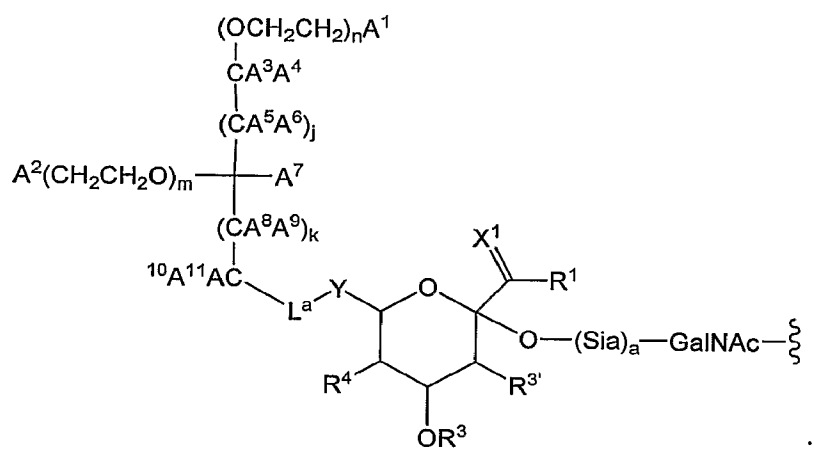
[0149] In another exemplary embodiment, the peptide conjugate comprises a glycosyl moiety selected from the formulae:

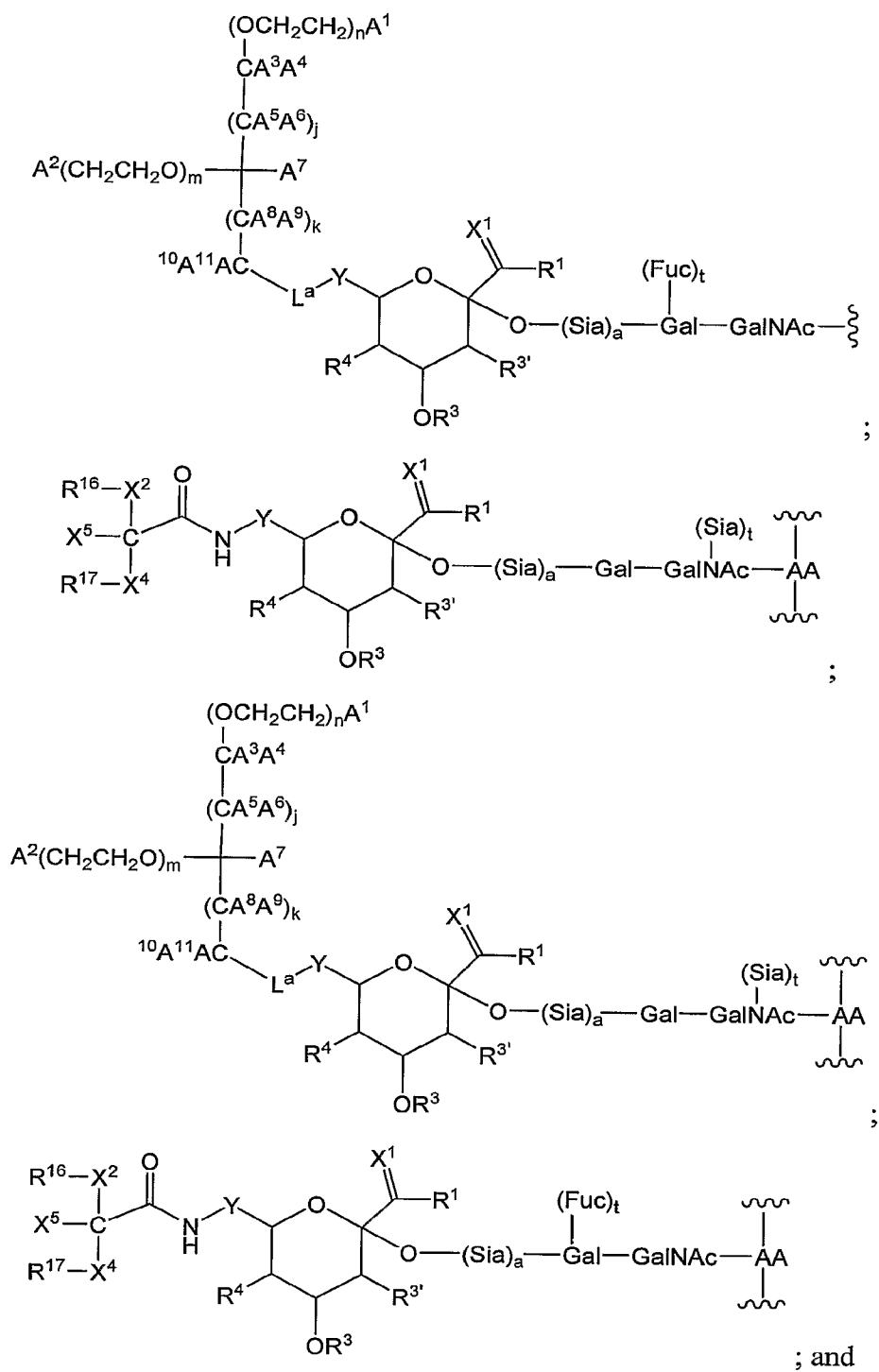


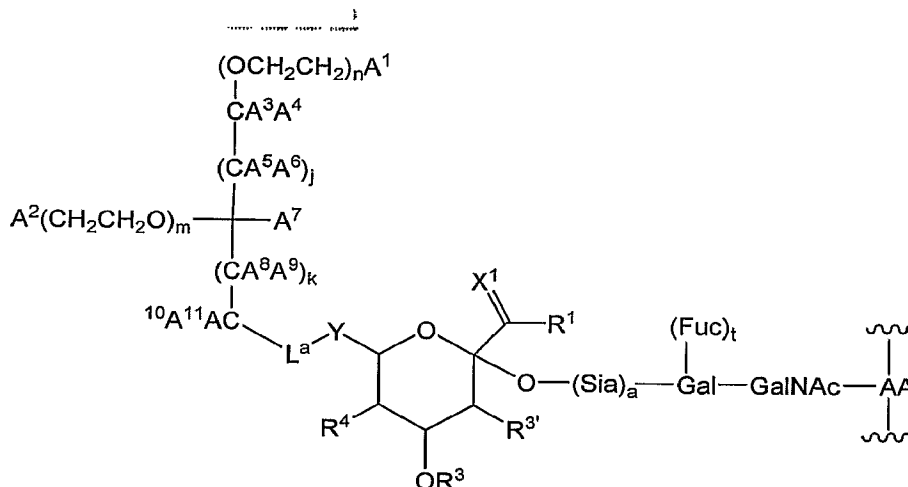












in which the index  $p$  is an integer from 1 to 10. The indices  $t$  and  $a$  are independently selected from 0 or 1. The indices  $m$  and  $n$  are integers independently selected from 0 to 5000. The indices  $j$  and  $k$  are integers independently selected from 0 to 20.  $A^1, A^2, A^3, A^4, A^5, A^6,$   
 5  $A^7, A^8, A^9, A^{10}$  and  $A^{11}$  are members independently selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl,  $-NA^{12}A^{13}, -OA^{12}$  and  $-SiA^{12}A^{13}$ .  $A^{12}$  and  $A^{13}$  are members independently selected from substituted or unsubstituted alkyl, substituted or  
 10 unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl. AA is an amino acid residue of the peptide. Each of these groups can be included as components of the mono-, bi-, tri- and tetra-antennary saccharide structures set forth above.  $L^a$  is a linker that results from the reaction of the polymer modifying group moiety  
 15 and the modified saccharyl fragment. Exemplary linking groups include substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl moieties. An exemplary component of the linker is an acyl moiety. Another exemplary linking group is an amino acid (e.g., cysteine, serine, lysine, and short oligopeptides, e.g., Lys-Lys, Lys-Lys-Lys, Cys-Lys, Ser-Lys, etc.).

## 20 Modifying Groups

[0150] The peptide conjugates of the invention comprise a modifying group. This group can be covalently attached to a peptide through an amino acid or a glycosyl linking group. “Modifying groups” can encompass a variety of structures including targeting moieties, therapeutic moieties, biomolecules. Additionally, “modifying groups” include polymeric

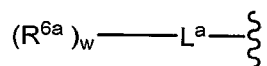
modifying groups, which can alter a property of the peptide such as its bioavailability or its half-life in the body.

[0151] In an exemplary embodiment, the modifying group is a targeting agent that localizes selectively in a particular tissue due to the presence of a targeting agent as a component of the conjugate. In an exemplary embodiment, the targeting agent is a protein. Exemplary proteins include transferrin (brain, blood pool), HS-glycoprotein (bone, brain, blood pool), antibodies (brain, tissue with antibody-specific antigen, blood pool), coagulation factors V-XII (damaged tissue, clots, cancer, blood pool), serum proteins, *e.g.*,  $\alpha$ -acid glycoprotein, fetuin,  $\alpha$ -fetal protein (brain, blood pool),  $\beta$ 2-glycoprotein (liver, atherosclerosis plaques, brain, blood pool), G-CSF, GM-CSF, M-CSF, and EPO (immune stimulation, cancers, blood pool, red blood cell overproduction, neuroprotection), albumin (increase in half-life), and lipoprotein E.

[0152] For the purposes of convenience, the modifying groups in the remainder of this section will be largely based on polymeric modifying groups such as water soluble and water insoluble polymers. However, one of skill in the art will recognize that other modifying groups, such as targeting moieties, therapeutic moieties and biomolecules, could be used in place of the polymeric modifying groups.

#### Linkers of the Modifying Groups

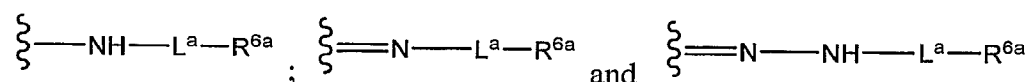
[0153] The linkers of the modifying group serve to attach the modifying group (ie polymeric modifying groups, targeting moieties, therapeutic moieties and biomolecules) to the glycosyl linking group. In an exemplary embodiment, the polymeric modifying group is bound to a glycosyl linking group, generally through a heteroatom, *e.g.*, nitrogen, on the core through a linker,  $L^a$ , as shown below:



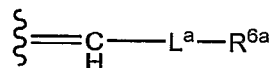
$R^{6a}$  is the polymeric modifying moiety and  $L^a$  is selected from a bond and a linking group. The index  $w$  represents an integer selected from 1-6, preferably 1-3 and more preferably 1-2. Exemplary linking groups include substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl moieties. An exemplary component of the linker is an acyl moiety.

[0154] In an exemplary embodiment, the invention has a structure according to Formula I above, in which  $Y^2$  is selected from the formulae:

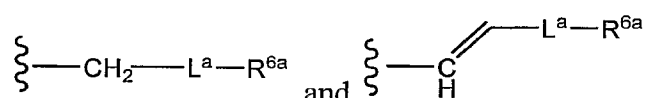




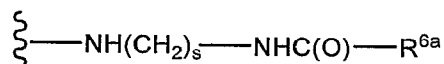
[0155] In another exemplary embodiment, the compound is the product of a Wittig reaction and  $Y^2$  has the formula:



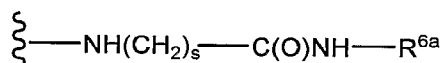
- 5 [0156] In another exemplary embodiment, the compound is formed from a reaction of the modified glycosyl linking fragment with a Grignard or lithium reagent and  $Y^2$  has a structure selected from the formulae:



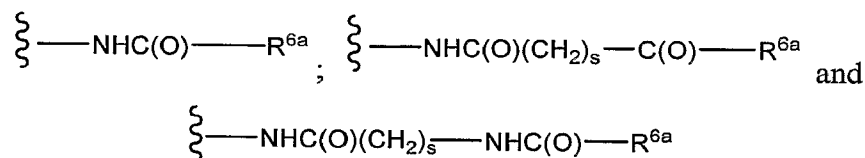
- 10 [0157] In yet another exemplary embodiment, the glycosyl linking group and the polymeric modifying group are linked through a diamine. In an exemplary compound according to this aspect of the invention  $Y^2$  has the formula:



- 15 [0158] In another exemplary embodiment the glycosyl linking group and the modifying group are linked through an aminocarboxylic acid. In an exemplary compound according to this aspect of the invention  $Y^2$  has the formula:

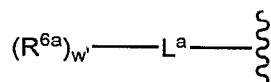


- 20 [0159] In yet another exemplary embodiment the aldehyde containing glycosyl linking group is reductively aminated with ammonia and the resulting amine is used to attach the polymeric modifying group, thereby forming an amide bond. In this aspect of the invention  $Y^2$  is selected from the formulae:



in which the index  $s$  is an integer from 0 to 20.

[0160] In an exemplary embodiment, the polymeric modifying group -linker construct is a branched structure that includes two or more polymeric chains attached to central moiety. In this embodiment, the construct has the formula:



5 in which  $R^{6a}$  and  $L^a$  are as discussed above and  $w$  is an integer from 2 to 6, preferably from 2 to 4 and more preferably from 2 to 3.

[0161] When  $L^a$  is a bond it is formed between a reactive functional group on a precursor of  $R^{6a}$  and a reactive functional group of complementary reactivity on the saccharyl core.

10 When  $L^a$  is a non-zero order linker, a precursor of  $L^a$  can be in place on the glycosyl moiety prior to reaction with the  $R^{6a}$  precursor. Alternatively, the precursors of  $R^{6a}$  and  $L^a$  can be incorporated into a preformed cassette that is subsequently attached to the glycosyl moiety. As set forth herein, the selection and preparation of precursors with appropriate reactive functional groups is within the ability of those skilled in the art. Moreover, coupling the precursors proceeds by chemistry that is well understood in the art.

15 [0162] In an exemplary embodiment,  $L^a$  is a linking group that is formed from an amino acid, or small peptide (*e.g.*, 1-4 amino acid residues) providing a modified sugar in which the polymeric modifying group is attached through a substituted alkyl linker. Exemplary linkers include glycine, lysine, serine and cysteine. The PEG moiety can be attached to the amine moiety of the linker through an amide or urethane bond. The PEG is linked to the sulfur or  
20 oxygen atoms of cysteine and serine through thioether or ether bonds, respectively.

#### Water-Soluble Polymers

[0163] Many water-soluble polymers are known to those of skill in the art and are useful in practicing the present invention. The term water-soluble polymer encompasses species such as saccharides (*e.g.*, dextran, amylose, hyalouronic acid, poly(sialic acid), heparans, heparins,  
25 etc.); poly (amino acids), *e.g.*, poly(aspartic acid) and poly(glutamic acid); nucleic acids; synthetic polymers (*e.g.*, poly(acrylic acid), poly(ethers), *e.g.*, poly(ethylene glycol); peptides, proteins, and the like. The present invention may be practiced with any water-soluble polymer with the sole limitation that the polymer must include a point at which the remainder of the conjugate can be attached.

[0164] Methods for activation of polymers can also be found in WO 94/17039, U.S. Pat. No. 5,324,844, WO 94/18247, WO 94/04193, U.S. Pat. No. 5,219,564, U.S. Pat. No. 5,122,614, WO 90/13540, U.S. Pat. No. 5,281,698, and more WO 93/15189, and for conjugation between activated polymers and peptides, *e.g.* Coagulation Factor VIII (WO 94/15625), hemoglobin (WO 94/09027), oxygen carrying molecule (U.S. Pat. No. 4,412,989), ribonuclease and superoxide dismutase (Veronese *et al.*, *App. Biochem. Biotech.* **11**: 141-45 (1985)).

[0165] Exemplary water-soluble polymers are those in which a substantial proportion of the polymer molecules in a sample of the polymer are of approximately the same molecular weight; such polymers are "homodisperse."

[0166] The present invention is further illustrated by reference to a poly(ethylene glycol) conjugate. Several reviews and monographs on the functionalization and conjugation of PEG are available. *See*, for example, Harris, *Macromol. Chem. Phys.* **C25**: 325-373 (1985); Scouten, *Methods in Enzymology* **135**: 30-65 (1987); Wong *et al.*, *Enzyme Microb. Technol.* **14**: 866-874 (1992); Delgado *et al.*, *Critical Reviews in Therapeutic Drug Carrier Systems* **9**: 249-304 (1992); Zalipsky, *Bioconjugate Chem.* **6**: 150-165 (1995); and Bhadra, *et al.*, *Pharmazie*, **57**:5-29 (2002). Routes for preparing reactive PEG molecules and forming conjugates using the reactive molecules are known in the art. For example, U.S. Patent No. 5,672,662 discloses a water soluble and isolatable conjugate of an active ester of a polymer acid selected from linear or branched poly(alkylene oxides), poly(oxyethylated polyols), poly(olefinic alcohols), and poly(acrylomorpholine).

[0167] U.S. Patent No. 6,376,604 sets forth a method for preparing a water-soluble 1-benzotriazolylcarbonate ester of a water-soluble and non-peptidic polymer by reacting a terminal hydroxyl of the polymer with di(1-benzotriazolyl)carbonate in an organic solvent. The active ester is used to form conjugates with a biologically active agent such as a protein or peptide.

[0168] WO 99/45964 describes a conjugate comprising a biologically active agent and an activated water soluble polymer comprising a polymer backbone having at least one terminus linked to the polymer backbone through a stable linkage, wherein at least one terminus comprises a branching moiety having proximal reactive groups linked to the branching moiety, in which the biologically active agent is linked to at least one of the proximal reactive groups. Other branched poly(ethylene glycols) are described in WO 96/21469, U.S. Patent

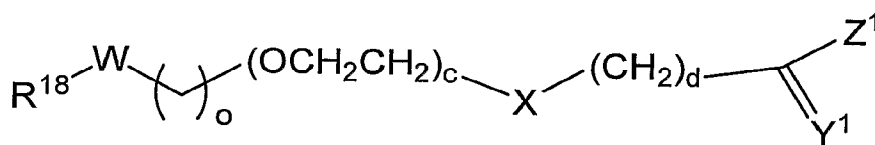
No. 5,932,462 describes a conjugate formed with a branched PEG molecule that includes a branched terminus that includes reactive functional groups. The free reactive groups are available to react with a biologically active species, such as a protein or peptide, forming conjugates between the poly(ethylene glycol) and the biologically active species. U.S. Patent  
 5 No. 5,446,090 describes a bifunctional PEG linker and its use in forming conjugates having a peptide at each of the PEG linker termini.

**[0169]** Conjugates that include degradable PEG linkages are described in WO 99/34833; and WO 99/14259, as well as in U.S. Patent No. 6,348,558. Such degradable linkages are applicable in the present invention.

10 **[0170]** The art-recognized methods of polymer activation set forth above are of use in the context of the present invention in the formation of the branched polymers set forth herein and also for the conjugation of these branched polymers to other species, *e.g.*, sugars, sugar nucleotides and the like.

15 **[0171]** An exemplary water-soluble polymer is poly(ethylene glycol), *e.g.*, methoxy-poly(ethylene glycol). The poly(ethylene glycol) used in the present invention is not restricted to any particular form or molecular weight range. For unbranched poly(ethylene glycol) molecules the molecular weight is preferably between 500 and 100,000. A molecular weight of 2000-60,000 is preferably used and preferably of from about 5,000 to about 40,000.

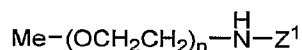
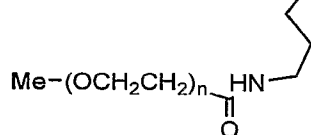
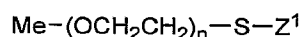
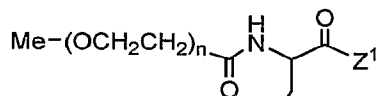
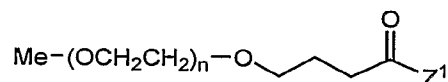
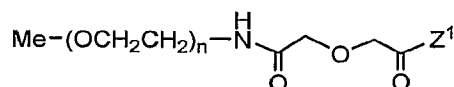
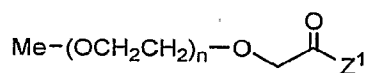
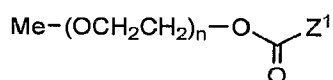
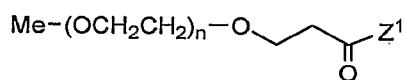
20 **[0172]** In an exemplary embodiment, poly(ethylene glycol) molecules of the invention include, but are not limited to, those species set forth below.



in which  $R^{18}$  is H, substituted or unsubstituted alkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted heteroalkyl, *e.g.*, acetal, OHC-,  $H_2N-CH_2CH_2-$ ,  $HS-CH_2CH_2-$ ,  
 25 and  $-(CH_2)_qC(Y^1)Z^2$ ; -sugar-nucleotide, or protein. The index "c" represents an integer from 1 to 2500. The indices d, o, and q independently represent integers from 0 to 20. The symbol  $Z^1$  represents OH,  $NH_2$ , halogen, S- $R^{19}$ , the alcohol portion of activated esters,  $-(CH_2)_{d1}C(Y^3)V$ ,  $-(CH_2)_{d1}U(CH_2)_gC(Y^3)_v$ , sugar-nucleotide, protein, and leaving groups, *e.g.*, imidazole, p-nitrophenyl, HOBt, tetrazole, halide. The symbols X,  $Y^1$ ,  $Y^3$ , W, U

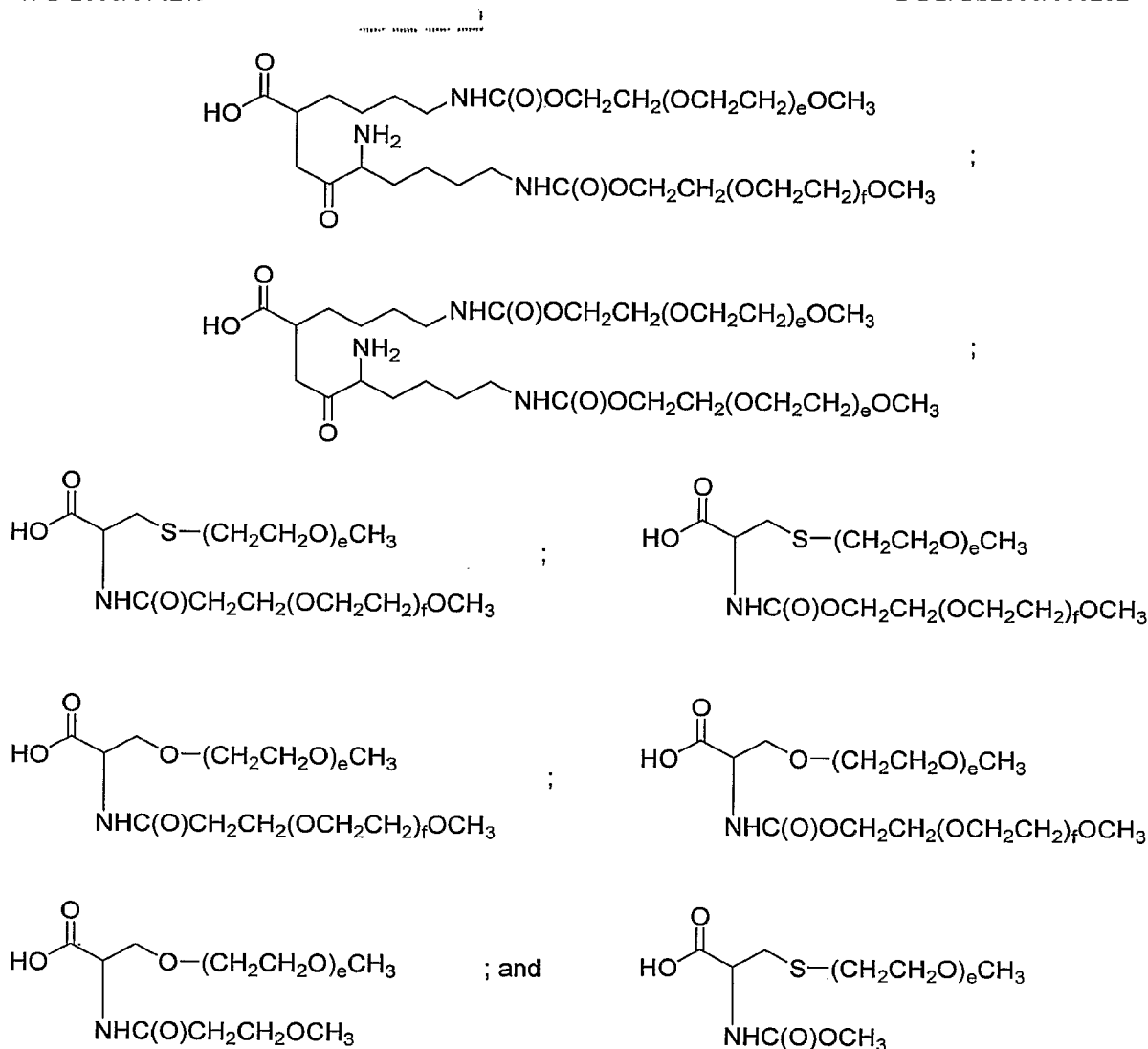
independently represent the moieties O, S, N-R<sup>20</sup>. The symbol V represents OH, NH<sub>2</sub>, halogen, S-R<sup>21</sup>, the alcohol component of activated esters, the amine component of activated amides, sugar-nucleotides, and proteins. The indices d1, g and v are members independently selected from the integers from 0 to 20. The symbols R<sup>19</sup>, R<sup>20</sup> and R<sup>21</sup> independently represent H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heterocycloalkyl and substituted or unsubstituted heteroaryl.

[0173] In other exemplary embodiments, the poly(ethylene glycol) molecule is selected from the following:



[0174] In another embodiment the poly(ethylene glycol) is a branched PEG having more than one PEG moiety attached. Examples of branched PEGs are described in U.S. Pat. No. 5,932,462; U.S. Pat. No. 5,342,940; U.S. Pat. No. 5,643,575; U.S. Pat. No. 5,919,455; U.S. Pat. No. 6,113,906; U.S. Pat. No. 5,183,660; WO 02/09766; Kodera Y., *Bioconjugate Chemistry* **5**: 283-288 (1994); and Yamasaki et al., *Agric. Biol. Chem.*, **52**: 2125-2127, 1998. In a preferred embodiment the molecular weight of each poly(ethylene glycol) of the branched PEG is less than or equal to 40,000 daltons.

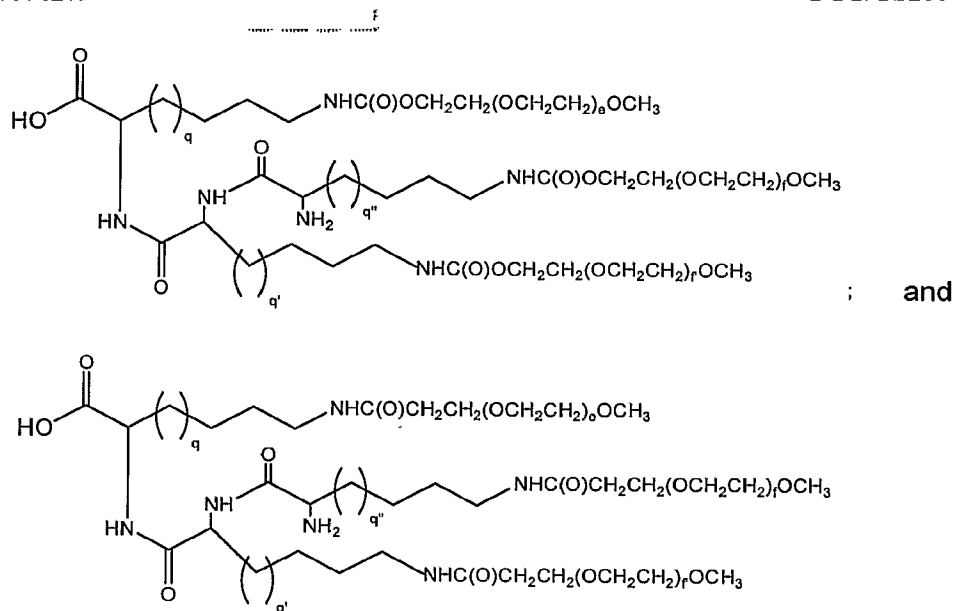
[0175] Representative polymeric modifying moieties include structures that are based on side chain-containing amino acids, e.g., serine, cysteine, lysine, and small peptides, e.g., lys-lys. Exemplary structures include:



Those of skill will appreciate that the free amine in the di-lysine structures can also be pegylated through an amide or urethane bond with a PEG moiety.

**[0176]** In yet another embodiment, the polymeric modifying moiety is a branched PEG moiety that is based upon a tri-lysine peptide. The tri-lysine can be mono-, di-, tri-, or tetra-PEG-ylated. Exemplary species according to this embodiment have the formulae:

5



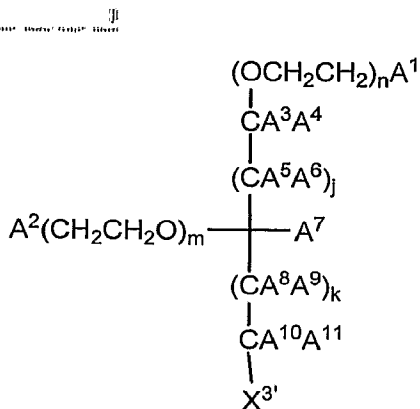
in which the indices e, f and f' are independently selected integers from 1 to 2500; and the indices q, q' and q'' are independently selected integers from 1 to 20.

[0177] As will be apparent to those of skill, the branched polymers of use in the invention include variations on the themes set forth above. For example the di-lysine-PEG conjugate shown above can include three polymeric subunits, the third bonded to the  $\alpha$ -amine shown as unmodified in the structure above. Similarly, the use of a tri-lysine functionalized with three or four polymeric subunits labeled with the polymeric modifying moiety in a desired manner is within the scope of the invention.

[0178] As discussed herein, the PEG of use in the conjugates of the invention can be linear or branched. An exemplary precursor of use to form the branched PEG containing peptide conjugates according to this embodiment of the invention has the formula:



Another exemplary precursor of use to form the branched PEG containing peptide conjugates according to this embodiment of the invention has the formula:



in which the indices  $m$  and  $n$  are integers independently selected from 0 to 5000. The indices  $t$  and  $a$  are independently selected from 0 or 1. The indices  $j$  and  $k$  are integers independently selected from 0 to 20.  $\text{A}^1, \text{A}^2, \text{A}^3, \text{A}^4, \text{A}^5, \text{A}^6, \text{A}^7, \text{A}^8, \text{A}^9, \text{A}^{10}$  and  $\text{A}^{11}$  are members

- 5 independently selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, - $\text{NA}^{12}\text{A}^{13}$ ,  $-\text{OA}^{12}$  and  $-\text{SiA}^{12}\text{A}^{13}$ .  $\text{A}^{12}$  and  $\text{A}^{13}$  are members independently selected from substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl.

- [0179] The branched polymer species according to this formula are essentially pure water-soluble polymers.  $\text{X}^{3'}$  is a moiety that includes an ionizable (*e.g.*, OH, COOH,  $\text{H}_2\text{PO}_4$ ,  $\text{HSO}_3$ ,  $\text{NH}_2$ , and salts thereof, etc.) or other reactive functional group, *e.g.*, *infra*. C is carbon.
- 15  $\text{X}^5, \text{R}^{16}$  and  $\text{R}^{17}$  are independently selected from non-reactive groups (*e.g.*, H, unsubstituted alkyl, unsubstituted heteroalkyl) and polymeric arms (*e.g.*, PEG).  $\text{X}^2$  and  $\text{X}^4$  are linkage fragments that are preferably essentially non-reactive under physiological conditions, which may be the same or different. An exemplary linker includes neither aromatic nor ester moieties. Alternatively, these linkages can include one or more moiety that is designed to
- 20 degrade under physiologically relevant conditions, *e.g.*, esters, disulfides, etc.  $\text{X}^2$  and  $\text{X}^4$  join polymeric arms  $\text{R}^{16}$  and  $\text{R}^{17}$  to C. When  $\text{X}^{3'}$  is reacted with a reactive functional group of complementary reactivity on a linker, sugar or linker-sugar cassette,  $\text{X}^{3'}$  is converted to a component of linkage fragment  $\text{X}^3$ .

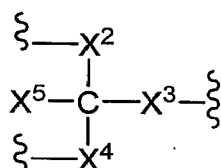
- [0180] Exemplary linkage fragments for  $\text{X}^2, \text{X}^3$  and  $\text{X}^4$  are independently selected and
- 25 include S,  $\text{SC}(\text{O})\text{NH}$ ,  $\text{HNC}(\text{O})\text{S}$ ,  $\text{SC}(\text{O})\text{O}$ , O, NH,  $\text{NHC}(\text{O})$ ,  $(\text{O})\text{CNH}$  and  $\text{NHC}(\text{O})\text{O}$ , and  $\text{OC}(\text{O})\text{NH}$ ,  $\text{CH}_2\text{S}$ ,  $\text{CH}_2\text{O}$ ,  $\text{CH}_2\text{CH}_2\text{O}$ ,  $\text{CH}_2\text{CH}_2\text{S}$ ,  $(\text{CH}_2)_6\text{O}$ ,  $(\text{CH}_2)_6\text{S}$  or  $(\text{CH}_2)_6\text{Y}'\text{-PEG}$



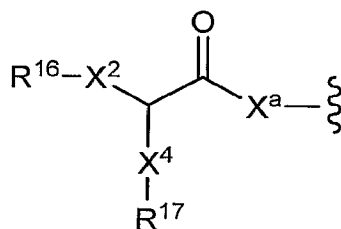
wherein, Y' is S, NH, NHC(O), C(O)NH, NHC(O)O, OC(O)NH, or O and o is an integer from 1 to 50. In an exemplary embodiment, the linkage fragments X<sup>2</sup> and X<sup>4</sup> are different linkage fragments.

[0181] In an exemplary embodiment, the precursor (Formula II), or an activated derivative thereof, is reacted with, and thereby bound to a sugar, an activated sugar or a sugar nucleotide through a reaction between X<sup>3'</sup> and a group of complementary reactivity on the sugar moiety, *e.g.*, an amine. Alternatively, X<sup>3'</sup> reacts with a reactive functional group on a precursor to linker, L.

[0182] In an exemplary embodiment, the moiety:



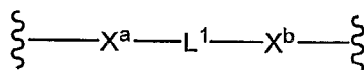
is the linker arm, L. In this embodiment, an exemplary linker is derived from a natural or unnatural amino acid, amino acid analogue or amino acid mimetic, or a small peptide formed from one or more such species. For example, certain branched polymers found in the compounds of the invention have the formula:



(III)

[0183] X<sup>a</sup> is a linkage fragment that is formed by the reaction of a reactive functional group, *e.g.*, X<sup>3'</sup>, on a precursor of the branched polymeric modifying moiety and a reactive functional group on the sugar moiety, or a precursor to a linker. For example, when X<sup>3'</sup> is a carboxylic acid, it can be activated and bound directly to an amine group pendent from an amino-saccharide (*e.g.*, Sia, GalNH<sub>2</sub>, GlcNH<sub>2</sub>, ManNH<sub>2</sub>, etc.), forming a X<sup>a</sup> that is an amide. Additional exemplary reactive functional groups and activated precursors are described hereinbelow. The index c represents an integer from 1 to 10. The other symbols have the same identity as those discussed above.

[0184] In another exemplary embodiment, X<sup>a</sup> is a linking moiety formed with another linker:

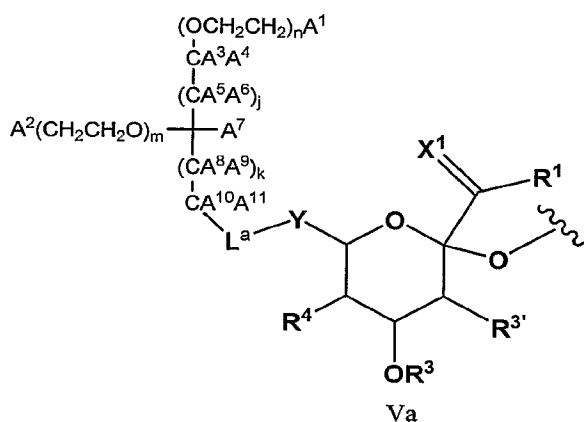
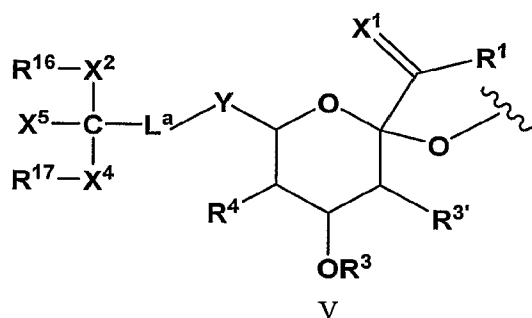


in which  $X^b$  is a second linkage fragment and is independently selected from those groups set forth for  $X^a$ , and, similar to  $L^a$ ,  $L^1$  is a bond, substituted or unsubstituted alkyl or substituted or unsubstituted heteroalkyl.

- 5 [0185] Exemplary species for  $X^a$  and  $X^b$  include S, SC(O)NH, HNC(O)S, SC(O)O, O, NH, NHC(O), C(O)NH and NHC(O)O, and OC(O)NH.

[0186] In another exemplary embodiment,  $X^4$  is a peptide bond to  $R^{17}$ , which is an amino acid, di-peptide (*e.g.*, Lys-Lys) or tri-peptide (*e.g.*, Lys-Lys-Lys) in which the alpha-amine moiety(ies) and/or side chain heteroatom(s) are modified with a polymeric modifying moiety.

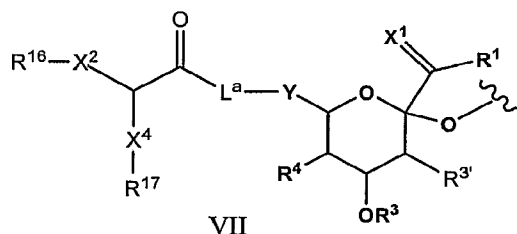
- 10 [0187] In a further exemplary embodiment, the peptide conjugates of the invention include a moiety, *e.g.*, an  $R^{15'}$  moiety that has a formula that is selected from:



- 15 in which the identity of the radicals represented by the various symbols is the same as that discussed hereinabove.  $L^a$  is a bond or a linker as discussed above for L and  $L^1$ , *e.g.*, substituted or unsubstituted alkyl or substituted or unsubstituted heteroalkyl moiety. In an exemplary embodiment,  $L^a$  is a moiety that is functionalized with the polymeric modifying moiety as shown. Exemplary  $L^a$  moieties include substituted or unsubstituted alkyl chains,

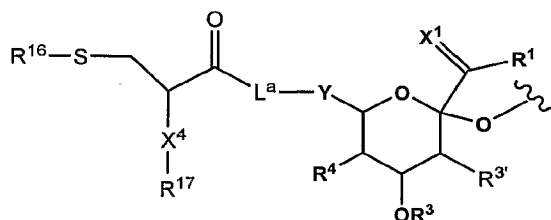
NH and NR<sup>6</sup>.

[0188] In yet another exemplary embodiment, the invention provides peptide conjugates having a moiety, *e.g.*, an R<sup>15'</sup> moiety with formula:



- 5 The identity of the radicals represented by the various symbols is the same as that discussed hereinabove. As those of skill will appreciate, the linker arm in Formula VII is equally applicable to other modified sugars set forth herein. In an exemplary embodiment, the species of Formula VII is the R<sup>15</sup> moieties attached to the glycan structures set forth herein.

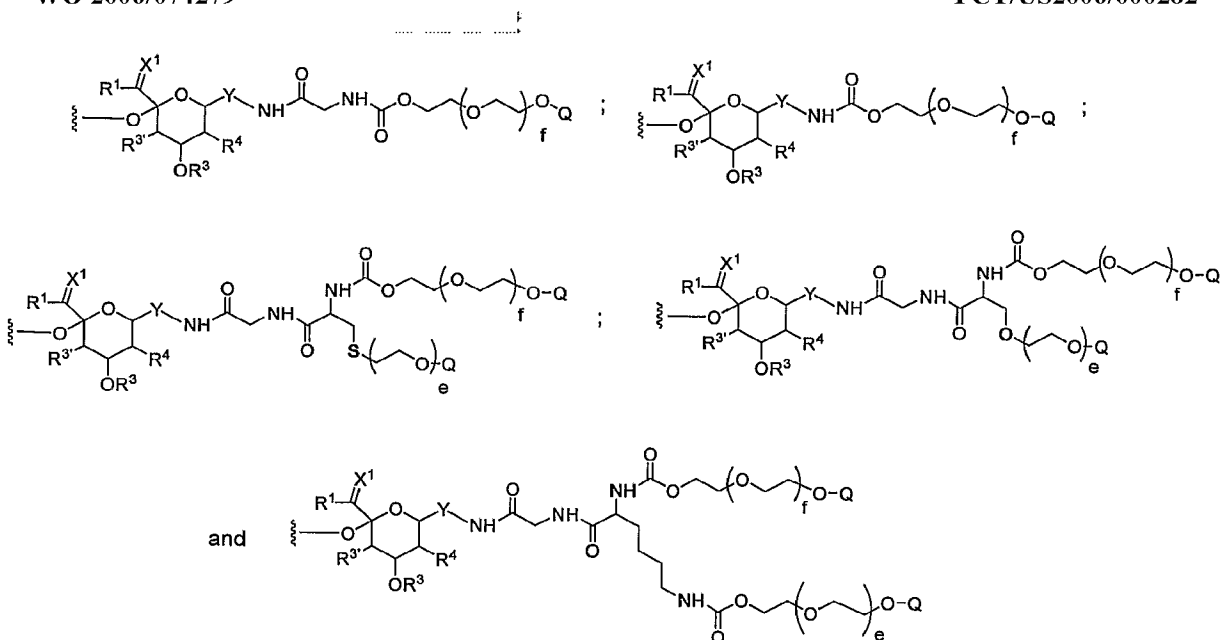
10 [0189] In an exemplary embodiment, the glycosyl linking group has a structure according to the following formula:



15 [0190] The embodiments of the invention set forth above are further exemplified by reference to species in which the polymer is a water-soluble polymer, particularly poly(ethylene glycol) ("PEG"), *e.g.*, methoxy-poly(ethylene glycol). Those of skill will appreciate that the focus in the sections that follow is for clarity of illustration and the various motifs set forth using PEG as an exemplary polymer are equally applicable to species in which a polymer other than PEG is utilized.

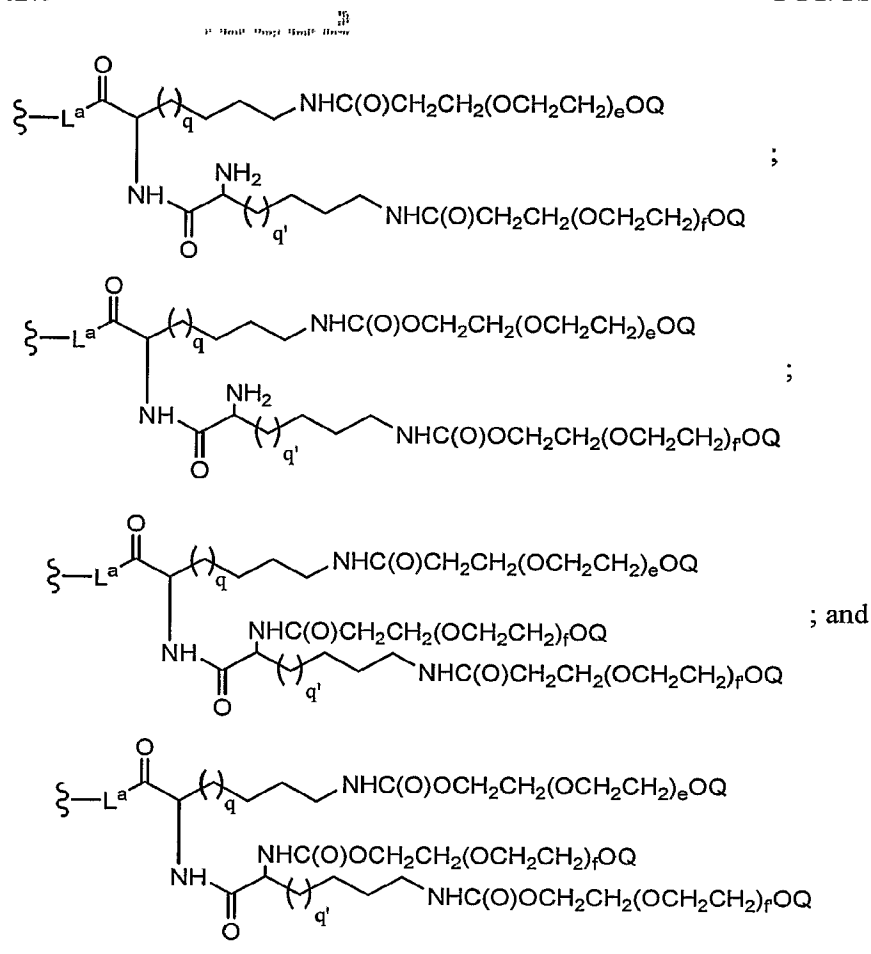
20 [0191] PEG of any molecular weight, *e.g.*, 1 kDa, 2 kDa, 5 kDa, 10 kDa, 15 kDa, 20 kDa, 25 kDa, 30 kDa, 35 kDa, 40 kDa, 45 kDa, 50 kDa, 55 kDa, 60 kDa, 65 kDa, 70 kDa, 75 kDa and 80 kDa is of use in the present invention.

[0192] In other exemplary embodiments, the peptide conjugate includes an R<sup>15'</sup> moiety selected from the group:

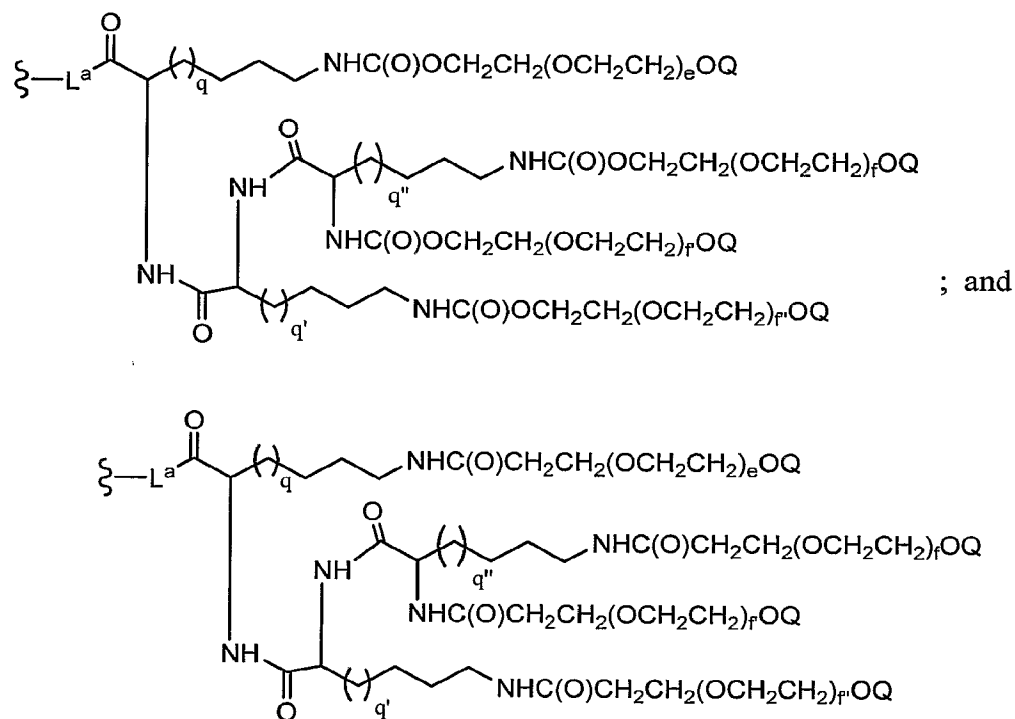


**[0193]** In each of the formulae above, the indices *e* and *f* are independently selected from the integers from 1 to 2500. In further exemplary embodiments, *e* and *f* are selected to provide a PEG moiety that is about 1 kDa, 2 kDa, 5 kDa, 10 kDa, 15 kDa, 20 kDa, 25 kDa, 30 kDa, 35 kDa, 40 kDa, 45 kDa, 50 kDa, 55 kDa, 60 kDa, 65 kDa, 70 kDa, 75 kDa and 80 kDa. The symbol *Q* represents substituted or unsubstituted alkyl (*e.g.*, C<sub>1</sub>-C<sub>6</sub> alkyl, *e.g.*, methyl), substituted or unsubstituted heteroalkyl or H.

**[0194]** Other branched polymers have structures based on di-lysine (Lys-Lys) peptides, *e.g.*:

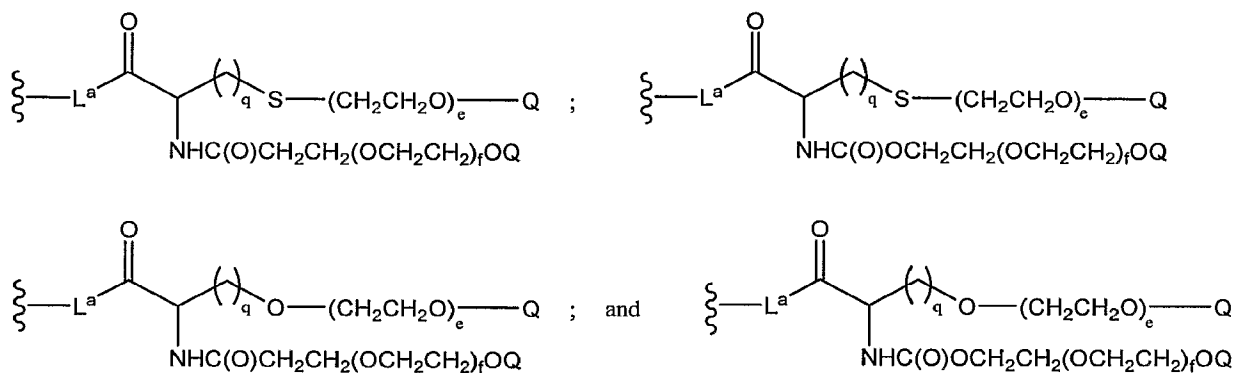


and tri-lysine peptides (Lys-Lys-Lys), *e.g.*:



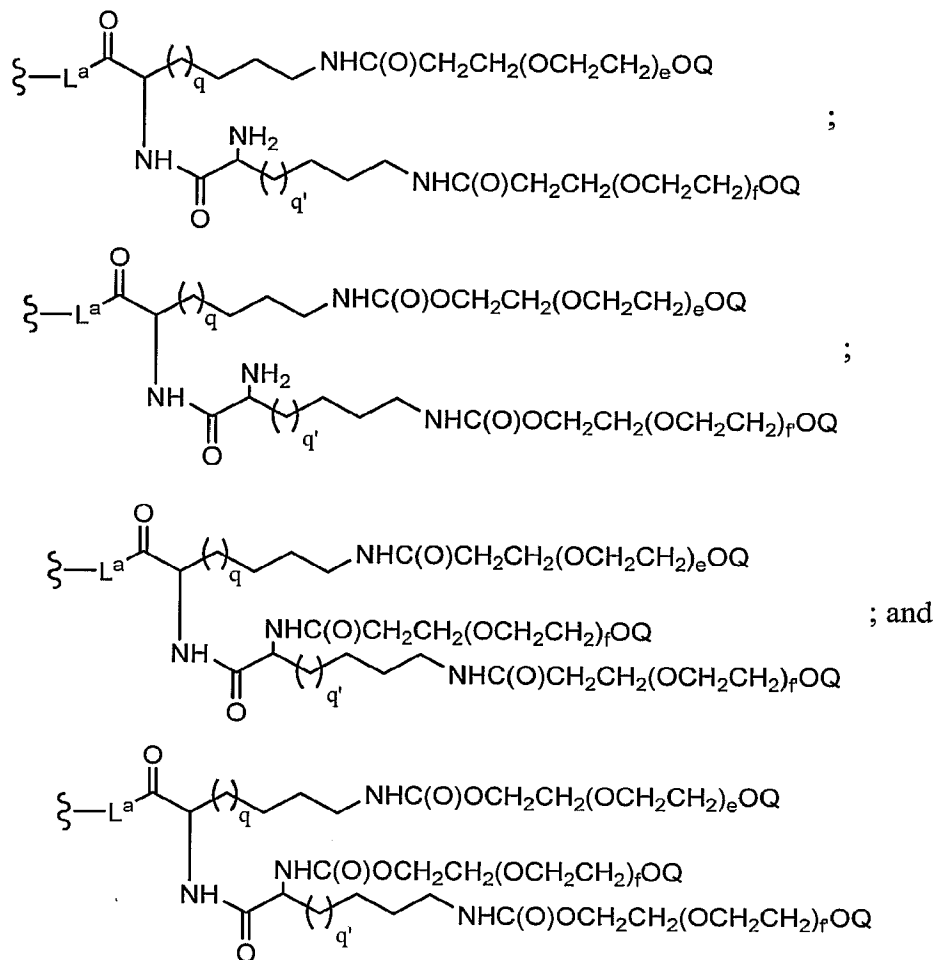
In each of the figures above, the indices  $e$ ,  $f$ ,  $f'$  and  $f''$  represent integers independently selected from 1 to 2500. The indices  $q$ ,  $q'$  and  $q''$  represent integers independently selected from 1 to 20.

**[0195]** In another exemplary embodiment, Y<sup>2</sup> has a formula that is a member selected from:



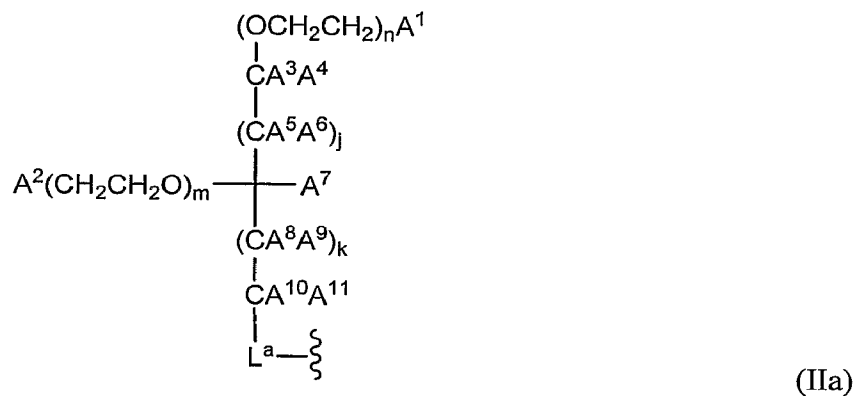
wherein Q is a member selected from H and substituted or unsubstituted C<sub>1</sub>-C<sub>6</sub> alkyl. The indices e and f are integers independently selected from 1 to 2500, and the index q is an integer selected from 0 to 20.

**[0196]** In another exemplary embodiment, Y<sup>2</sup> has a formula that is a member selected from:



wherein Q is a member selected from H and substituted or unsubstituted C<sub>1</sub>-C<sub>6</sub> alkyl. The indices e, f and f' are integers independently selected from 1 to 2500, and q and q' are integers independently selected from 1 to 20.

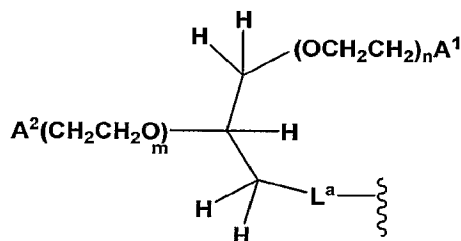
- 5 [0197] In another exemplary embodiment, the branched polymer has a structure according to the following formula:



in which the indices m and n are integers independently selected from 0 to 5000. The indices t and a are independently selected from 0 or 1. The indices j and k are integers independently selected from 0 to 20.  $A^1, A^2, A^3, A^4, A^5, A^6, A^7, A^8, A^9, A^{10}$  and  $A^{11}$  are members independently selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, - $NA^{12}A^{13}$ , - $OA^{12}$  and - $SiA^{12}A^{13}$ .  $A^{12}$  and  $A^{13}$  are members independently selected from substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted cycloalkyl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted aryl, and substituted or unsubstituted heteroaryl.

[0198] Formula IIa is a subset of Formula II. The structures described by Formula IIa are also encompassed by Formula II.

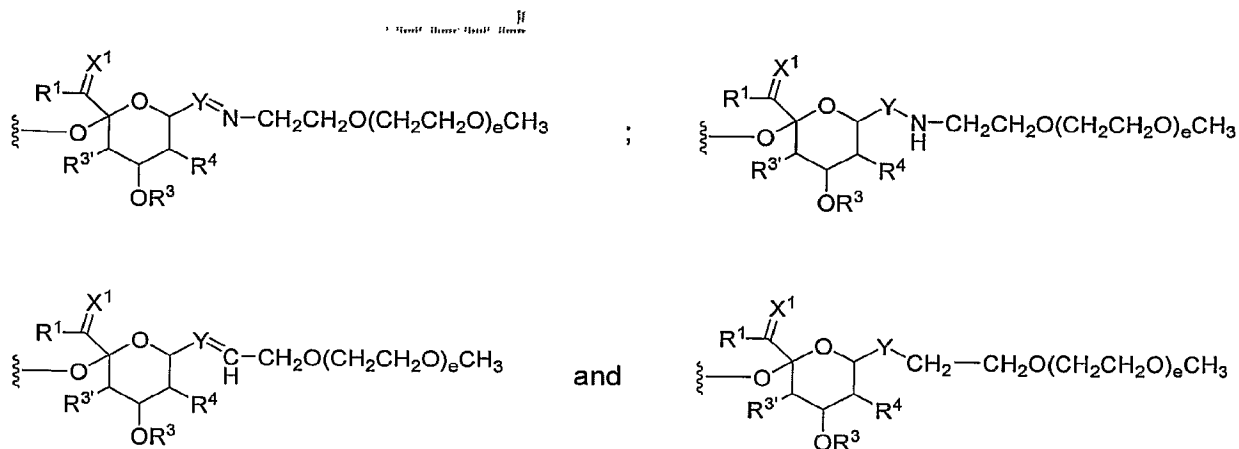
[0199] In another exemplary embodiment according to the formula above, the branched polymer has a structure according to the following formula:



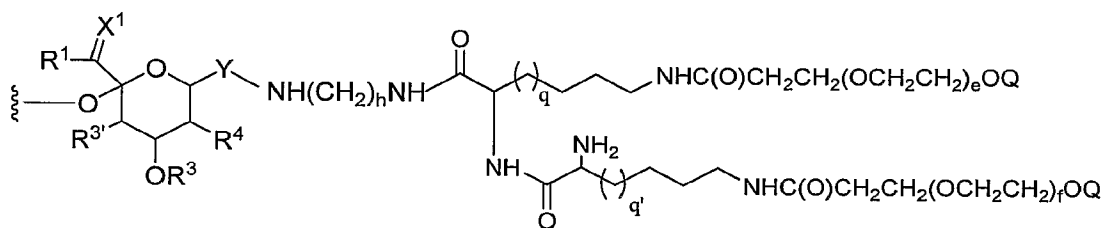
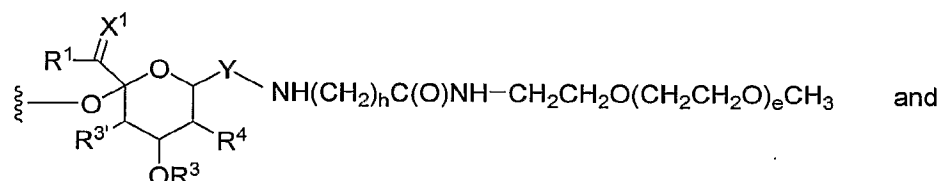
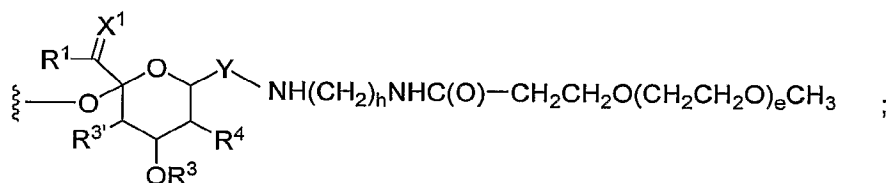
In an exemplary embodiment,  $A^1$  and  $A^2$  are each  $-OCH_3$  or H.

[0200] In an exemplary embodiment the modified saccharyl fragment is linked to the polymeric modifying group by reacting the aldehyde group of the oxidized sialyl side chain with a Grignard reagent or a Wittig reagent or an appropriate amine containing reagent, thereby forming an imine, which is alternatively reduced. Formulae according to this embodiment include:



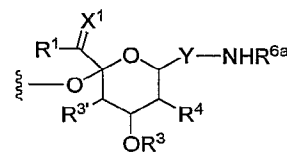
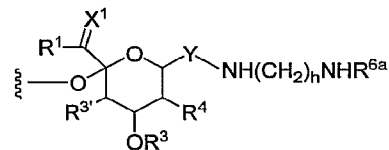
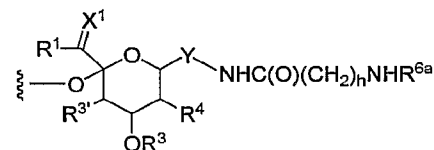
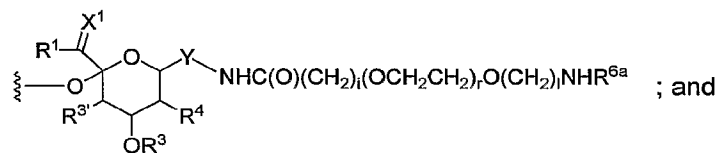
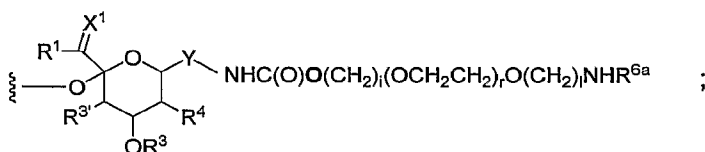
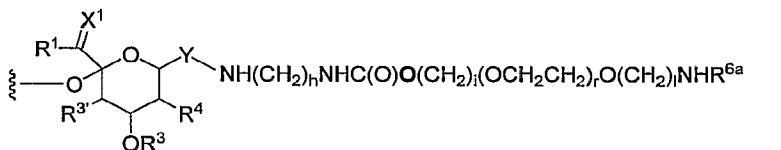
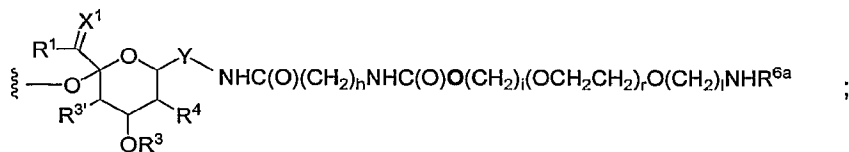
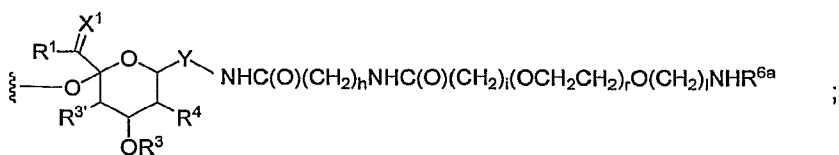


[0201] In another exemplary embodiment the modified saccharyl fragment is linked to the polymeric modifying group through a diamino alkyl linker or an amino carboxylic acid linker. Formulae according to this embodiment include:



in which the index h is an integer from 0 to 20 and the indices q, q', e and f are as defined above.

[0202] In an illustrative embodiment, the aldehyde group of the oxidized sialyl side chain of the modified saccharyl fragment is functionalized with the modifying group. For example, the aldehyde is reductively aminated with ammonia. The resulting primary amine is functionalized to provide a compound according to the invention. Formulae according to this embodiment include:



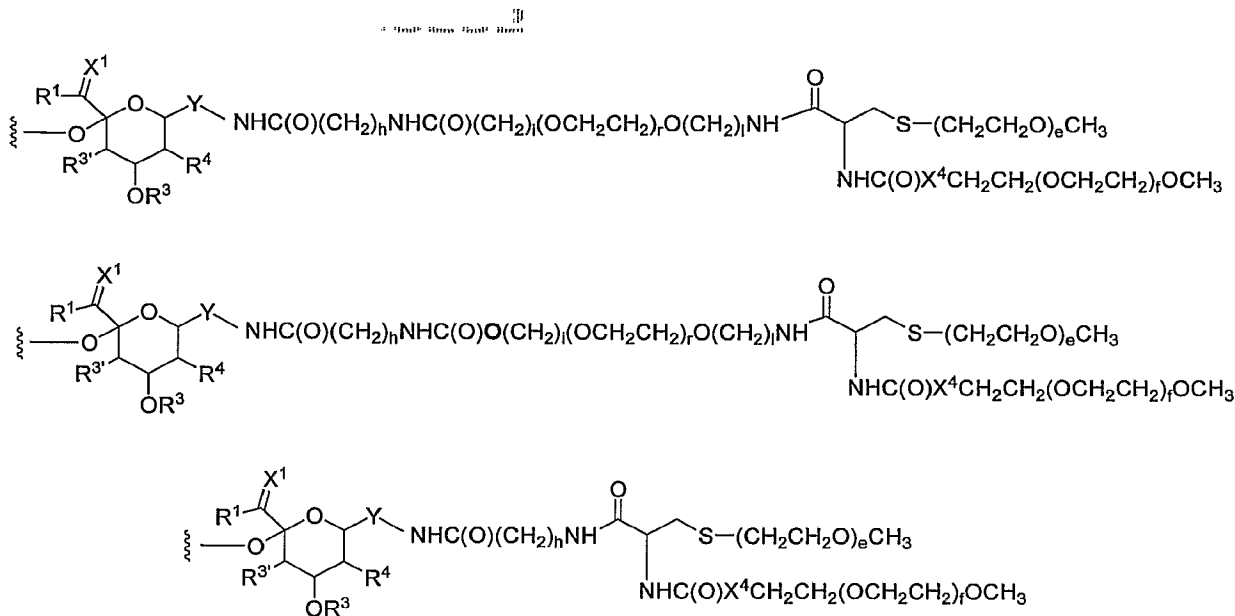
The indices h, i and l are integers from 0 to 20. The index r is an integer from 1 to 2500. The structures set forth above can be components of R<sup>15'</sup>.

[0203] Although the present invention is exemplified in the preceding sections by

5 reference to PEG, as those of skill will appreciate, an array of polymeric modifying moieties is of use in the compounds and methods set forth herein.

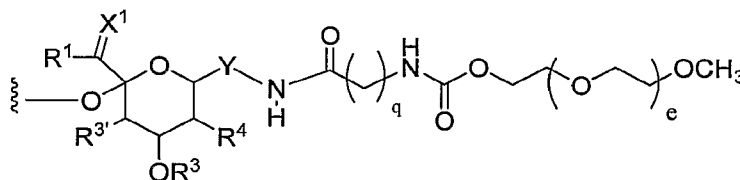
[0204] In selected embodiments, R<sup>6a</sup> or L- R<sup>6b</sup> is a branched PEG, for example, one of the species set forth above. In an exemplary embodiment, the branched PEG structure is based on a cysteine peptide. Illustrative modified saccharyl fragments according to this

10 embodiment include:



in which  $X^4$  is a bond or O. In each of the structures above, the alkylamine linker –  $\text{NHC(O)(CH}_2)_h\text{--}$  can be present or absent. The structures set forth above can be components of  $R^{15}/R^{15'}$ .

- 5 [0205] As discussed herein, the polymeric modifying groups of use in the invention may also be linear structures. Thus, the invention provides for conjugates that include a modified saccharyl fragment derived from a structure such as:

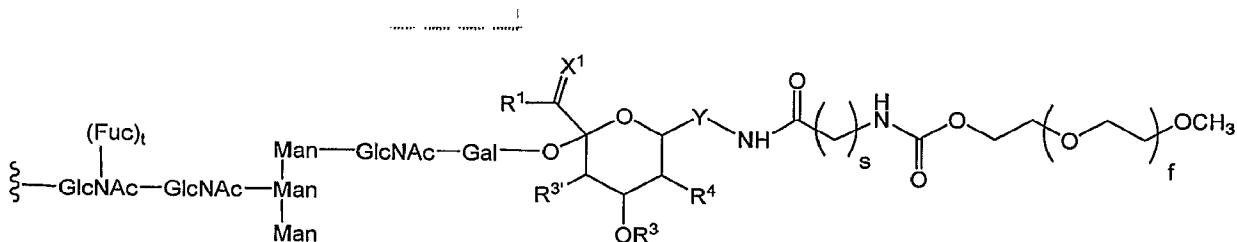


in which the indices  $q$  and  $e$  are as discussed above.

- 10 [0206] Exemplary modified sugars are modified with water-soluble or water-insoluble polymers. Examples of useful polymer are further exemplified below.

[0207] In another exemplary embodiment, the peptide is derived from insect cells, remodeled by adding GlcNAc and Gal to the mannose core and glycopegylated using a sialic acid bearing a linear PEG moiety, affording a peptide conjugate that comprises at least one moiety having the formula:

15



in which the index  $t$  is an integer from 0 to 1; the index  $s$  represents an integer from 1 to 10; and the index  $f$  represents an integer from 1 to 2500.

### Water-Insoluble Polymers

5     **[0208]**     In another embodiment, analogous to those discussed above, the modified sugars include a water-insoluble polymer, rather than a water-soluble polymer. The conjugates of the invention may also include one or more water-insoluble polymers. This embodiment of the invention is illustrated by the use of the conjugate as a vehicle with which to deliver a therapeutic peptide in a controlled manner. Polymeric drug delivery systems are known in  
10    the art. *See*, for example, Dunn *et al.*, Eds. POLYMERIC DRUGS AND DRUG DELIVERY SYSTEMS, ACS Symposium Series Vol. 469, American Chemical Society, Washington, D.C. 1991. Those of skill in the art will appreciate that substantially any known drug delivery system is applicable to the conjugates of the present invention.

**[0209]** The motifs set forth above for R<sup>6a</sup>, L<sup>a</sup>-R<sup>6a</sup>, R<sup>15</sup>, R<sup>15'</sup> and other radicals are equally applicable to water-insoluble polymers, which may be incorporated into the linear and branched structures without limitation utilizing chemistry readily accessible to those of skill in the art. Similarly, the incorporation of these species into any of the modified sugars discussed herein is within the scope of the present invention. Accordingly, the invention provides conjugates containing, and for the use of to prepare such conjugates, sialic acid and other sugar moieties modified with a linear or branched water-insoluble polymers, and activated analogues of the modified sialic acid species (*e.g.*, CMP-Sia-(water insoluble polymer)).

**[0210]** Representative water-insoluble polymers include, but are not limited to, polyphosphazines, poly(vinyl alcohols), polyamides, polycarbonates, polyalkylenes, polyacrylamides, polyalkylene glycols, polyalkylene oxides, polyalkylene terephthalates, polyvinyl ethers, polyvinyl esters, polyvinyl halides, polyvinylpyrrolidone, polyglycolides, polysiloxanes, polyurethanes, poly(methyl methacrylate), poly(ethyl methacrylate), poly(butyl methacrylate), poly(isobutyl methacrylate), poly(hexyl methacrylate),

poly(isodecyl methacrylate), poly(lauryl methacrylate), poly(phenyl methacrylate), poly(methyl acrylate), poly(isopropyl acrylate), poly(isobutyl acrylate), poly(octadecyl acrylate) polyethylene, polypropylene, poly(ethylene glycol), poly(ethylene oxide), poly(ethylene terephthalate), poly(vinyl acetate), polyvinyl chloride, polystyrene, polyvinyl pyrrolidone, pluronics and polyvinylphenol and copolymers thereof.

[0211] Synthetically modified natural polymers of use in conjugates of the invention include, but are not limited to, alkyl celluloses, hydroxyalkyl celluloses, cellulose ethers, cellulose esters, and nitrocelluloses. Particularly preferred members of the broad classes of synthetically modified natural polymers include, but are not limited to, methyl cellulose, ethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methyl cellulose, hydroxybutyl methyl cellulose, cellulose acetate, cellulose propionate, cellulose acetate butyrate, cellulose acetate phthalate, carboxymethyl cellulose, cellulose triacetate, cellulose sulfate sodium salt, and polymers of acrylic and methacrylic esters and alginic acid.

[0212] These and the other polymers discussed herein can be readily obtained from commercial sources such as Sigma Chemical Co. (St. Louis, MO.), Polysciences (Warrenton, PA.), Aldrich (Milwaukee, WI.), Fluka (Ronkonkoma, NY), and BioRad (Richmond, CA), or else synthesized from monomers obtained from these suppliers using standard techniques.

[0213] Representative biodegradable polymers of use in the conjugates of the invention include, but are not limited to, polylactides, polyglycolides and copolymers thereof, poly(ethylene terephthalate), poly(butyric acid), poly(valeric acid), poly(lactide-co-caprolactone), poly(lactide-co-glycolide), polyanhydrides, polyorthoesters, blends and copolymers thereof. Of particular use are compositions that form gels, such as those including collagen, pluronics and the like.

[0214] The polymers of use in the invention include "hybrid" polymers that include water-insoluble materials having within at least a portion of their structure, a bioresorbable molecule. An example of such a polymer is one that includes a water-insoluble copolymer, which has a bioresorbable region, a hydrophilic region and a plurality of crosslinkable functional groups per polymer chain.

[0215] For purposes of the present invention, "water-insoluble materials" includes materials that are substantially insoluble in water or water-containing environments. Thus, although certain regions or segments of the copolymer may be hydrophilic or even water-



soluble, the polymer molecule, as a whole, does not to any substantial measure dissolve in water.

[0216] For purposes of the present invention, the term "bioresorbable molecule" includes a region that is capable of being metabolized or broken down and resorbed and/or eliminated through normal excretory routes by the body. Such metabolites or break down products are preferably substantially non-toxic to the body.

[0217] The bioresorbable region may be either hydrophobic or hydrophilic, so long as the copolymer composition as a whole is not rendered water-soluble. Thus, the bioresorbable region is selected based on the preference that the polymer, as a whole, remains water-insoluble. Accordingly, the relative properties, *i.e.*, the kinds of functional groups contained by, and the relative proportions of the bioresorbable region, and the hydrophilic region are selected to ensure that useful bioresorbable compositions remain water-insoluble.

[0218] Exemplary resorbable polymers include, for example, synthetically produced resorbable block copolymers of poly( $\alpha$ -hydroxy-carboxylic acid)/poly(oxyalkylene, (*see*, Cohn *et al.*, U.S. Patent No. 4,826,945). These copolymers are not crosslinked and are water-soluble so that the body can excrete the degraded block copolymer compositions. *See*, Younes *et al.*, *J Biomed. Mater. Res.* **21**: 1301-1316 (1987); and Cohn *et al.*, *J Biomed. Mater. Res.* **22**: 993-1009 (1988).

[0219] Presently preferred bioresorbable polymers include one or more components selected from poly(esters), poly(hydroxy acids), poly(lactones), poly(amides), poly(ester-amides), poly (amino acids), poly(anhydrides), poly(orthoesters), poly(carbonates), poly(phosphazines), poly(phosphoesters), poly(thioesters), polysaccharides and mixtures thereof. More preferably still, the biosresorbable polymer includes a poly(hydroxy) acid component. Of the poly(hydroxy) acids, polylactic acid, polyglycolic acid, polycaproic acid, polybutyric acid, polyvaleric acid and copolymers and mixtures thereof are preferred.

[0220] In addition to forming fragments that are absorbed *in vivo* ("bioresorbed"), preferred polymeric coatings for use in the methods of the invention can also form an excretable and/or metabolizable fragment.

[0221] Higher order copolymers can also be used in the present invention. For example, Casey *et al.*, U.S. Patent No. 4,438,253, which issued on March 20, 1984, discloses tri-block copolymers produced from the transesterification of poly(glycolic acid) and an hydroxyl-

ended poly(alkylene glycol). Such compositions are disclosed for use as resorbable monofilament sutures. The flexibility of such compositions is controlled by the incorporation of an aromatic orthocarbonate, such as tetra-p-tolyl orthocarbonate into the copolymer structure.

5 [0222] Other polymers based on lactic and/or glycolic acids can also be utilized. For example, Spinu, U.S. Patent No. 5,202,413, which issued on April 13, 1993, discloses biodegradable multi-block copolymers having sequentially ordered blocks of polylactide and/or polyglycolide produced by ring-opening polymerization of lactide and/or glycolide onto either an oligomeric diol or a diamine residue followed by chain extension with a di-  
10 functional compound, such as, a diisocyanate, diacylchloride or dichlorosilane.

[0223] Bioresorbable regions of coatings useful in the present invention can be designed to be hydrolytically and/or enzymatically cleavable. For purposes of the present invention, "hydrolytically cleavable" refers to the susceptibility of the copolymer, especially the bioresorbable region, to hydrolysis in water or a water-containing environment. Similarly,  
15 "enzymatically cleavable" as used herein refers to the susceptibility of the copolymer, especially the bioresorbable region, to cleavage by endogenous or exogenous enzymes.

[0224] When placed within the body, the hydrophilic region can be processed into excretable and/or metabolizable fragments. Thus, the hydrophilic region can include, for example, polyethers, polyalkylene oxides, polyols, poly(vinyl pyrrolidine), poly(vinyl  
20 alcohol), poly(alkyl oxazolines), polysaccharides, carbohydrates, peptides, proteins and copolymers and mixtures thereof. Furthermore, the hydrophilic region can also be, for example, a poly(alkylene) oxide. Such poly(alkylene) oxides can include, for example, poly(ethylene) oxide, poly(propylene) oxide and mixtures and copolymers thereof.

[0225] Polymers that are components of hydrogels are also useful in the present invention.  
25 Hydrogels are polymeric materials that are capable of absorbing relatively large quantities of water. Examples of hydrogel forming compounds include, but are not limited to, polyacrylic acids, sodium carboxymethylcellulose, polyvinyl alcohol, polyvinyl pyrrolidine, gelatin, carrageenan and other polysaccharides, hydroxyethylenemethacrylic acid (HEMA), as well as derivatives thereof, and the like. Hydrogels can be produced that are stable, biodegradable  
30 and bioresorbable. Moreover, hydrogel compositions can include subunits that exhibit one or more of these properties.

[0226] Bio-compatible hydrogel compositions whose integrity can be controlled through crosslinking are known and are presently preferred for use in the methods of the invention. For example, Hubbell *et al.*, U.S. Patent Nos. 5,410,016, which issued on April 25, 1995 and 5,529,914, which issued on June 25, 1996, disclose water-soluble systems, which are crosslinked block copolymers having a water-soluble central block segment sandwiched between two hydrolytically labile extensions. Such copolymers are further end-capped with photopolymerizable acrylate functionalities. When crosslinked, these systems become hydrogels. The water soluble central block of such copolymers can include poly(ethylene glycol); whereas, the hydrolytically labile extensions can be a poly( $\alpha$ -hydroxy acid), such as polyglycolic acid or polylactic acid. *See*, Sawhney *et al.*, *Macromolecules* **26**: 581-587 (1993).

[0227] In another preferred embodiment, the gel is a thermoreversible gel. Thermoreversible gels including components, such as pluronics, collagen, gelatin, hyalouronic acid, polysaccharides, polyurethane hydrogel, polyurethane-urea hydrogel and combinations thereof are presently preferred.

[0228] In yet another exemplary embodiment, the conjugate of the invention includes a component of a liposome. Liposomes can be prepared according to methods known to those skilled in the art, for example, as described in Eppstein *et al.*, U.S. Patent No. 4,522,811. For example, liposome formulations may be prepared by dissolving appropriate lipid(s) (such as stearyl phosphatidyl ethanolamine, stearyl phosphatidyl choline, arachadyl phosphatidyl choline, and cholesterol) in an inorganic solvent that is then evaporated, leaving behind a thin film of dried lipid on the surface of the container. An aqueous solution of the active compound or its pharmaceutically acceptable salt is then introduced into the container. The container is then swirled by hand to free lipid material from the sides of the container and to disperse lipid aggregates, thereby forming the liposomal suspension.

[0229] The above-recited microparticles and methods of preparing the microparticles are offered by way of example and they are not intended to define the scope of microparticles of use in the present invention. It will be apparent to those of skill in the art that an array of microparticles, fabricated by different methods, is of use in the present invention.

[0230] The structural formats discussed above in the context of the water-soluble polymers, both straight-chain and branched are generally applicable with respect to the water-insoluble polymers as well. Thus, for example, the cysteine, serine, dilysine, and trylsine



branching cores can be functionalized with two water-insoluble polymer moieties. The methods used to produce these species are generally closely analogous to those used to produce the water-soluble polymers.

### Biomolecules

- 5 [0231] In another exemplary embodiment, the modified saccharyl fragment bears a biomolecule. In still further preferred embodiments, the biomolecule is a functional protein, enzyme, antigen, antibody, peptide, nucleic acid (*e.g.*, single nucleotides or nucleosides, oligonucleotides, polynucleotides and single- and higher-stranded nucleic acids), lectin, receptor or a combination thereof.
- 10 [0232] In a presently preferred embodiment, the modifying group is biotin. In an exemplary embodiment, the selectively biotinylated peptide is elaborated by the attachment of an avidin or streptavidin moiety bearing one or more modifying groups. Preferred biomolecules are essentially non-fluorescent, or emit such a minimal amount of fluorescence that they are inappropriate for use as a fluorescent marker in an assay. Moreover, it is
- 15 generally preferred to use biomolecules that are not sugars. An exception to this preference is the use of an otherwise naturally occurring sugar that is modified by covalent attachment of another entity (*e.g.*, PEG, biomolecule, therapeutic moiety, diagnostic moiety, *etc.*). In an exemplary embodiment, a sugar moiety, which is a biomolecule, is conjugated to a linker arm and the sugar-linker arm cassette is subsequently conjugated to a peptide via a method of the
- 20 invention.

- [0233] Biomolecules useful in practicing the present invention can be derived from any source. The biomolecules can be isolated from natural sources or they can be produced by synthetic methods. Peptides can be natural peptides or mutated peptides. Mutations can be effected by chemical mutagenesis, site-directed mutagenesis or other means of inducing
- 25 mutations known to those of skill in the art. Peptides useful in practicing the instant invention include, for example, enzymes, antigens, antibodies and receptors. Antibodies can be either polyclonal or monoclonal.

- [0234] Both naturally derived and synthetic peptides and nucleic acids are of use in conjunction with the present invention; these molecules can be attached to a sugar residue
- 30 component or a crosslinking agent by any available reactive group. For example, peptides can be attached through a reactive amine, carboxyl, sulfhydryl, or hydroxyl group. The reactive group can reside at a peptide terminus or at a site internal to the peptide chain.

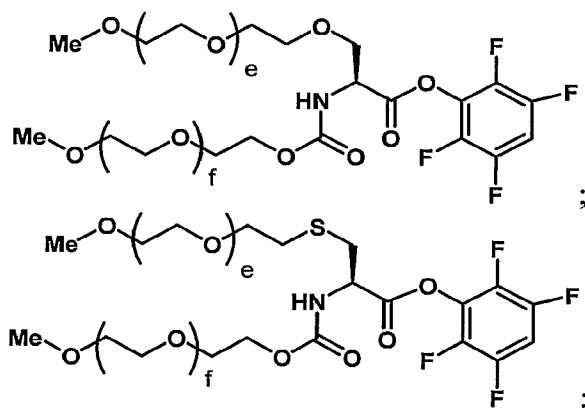
Nucleic acids can be attached through a reactive group on a base (*e.g.*, exocyclic amine) or an available hydroxyl group on a sugar moiety (*e.g.*, 3'- or 5'-hydroxyl). The peptide and nucleic acid chains can be further derivatized at one or more sites to allow for the attachment of appropriate reactive groups onto the chain. *See, Chrisey et al. Nucleic Acids Res.* **24**:

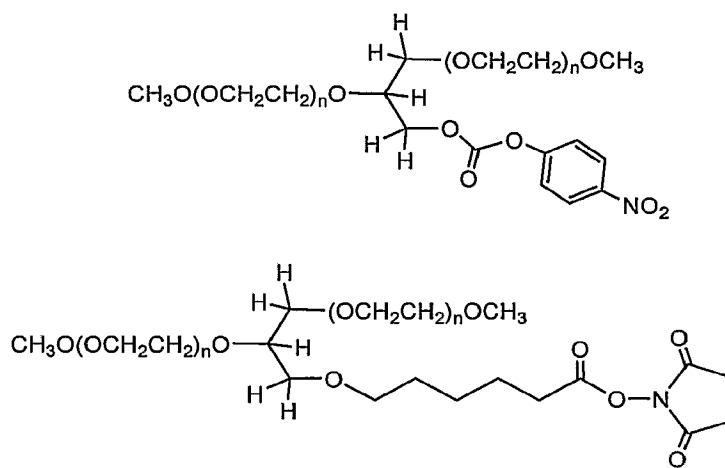
5 3031-3039 (1996).

[0235] In a further preferred embodiment, the biomolecule is selected to direct the peptide modified by the methods of the invention to a specific tissue, thereby enhancing the delivery of the peptide to that tissue relative to the amount of underivatized peptide that is delivered to the tissue. In a still further preferred embodiment, the amount of derivatized peptide delivered to a specific tissue within a selected time period is enhanced by derivatization by at least about 20%, more preferably, at least about 40%, and more preferably still, at least about 100%. Presently, preferred biomolecules for targeting applications include antibodies, hormones and ligands for cell-surface receptors.

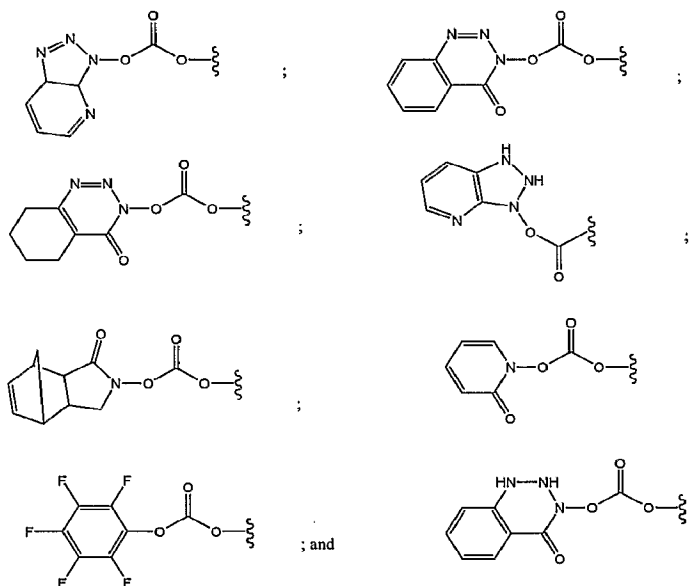
## 15 ***II. D. v. Methods of Producing the Polymeric Modifying Groups***

[0236] The polymeric modifying groups can be activated for reaction with a glycosyl or saccharyl moiety, an amino acid moiety, an amine or with other nucleophiles. Exemplary structures of activated species (*e.g.*, carbonates and active esters) include:





**[0237]** Other activating, or leaving groups, appropriate for activating linear and branched PEGs of use in preparing the compounds set forth herein include, but are not limited to the species:

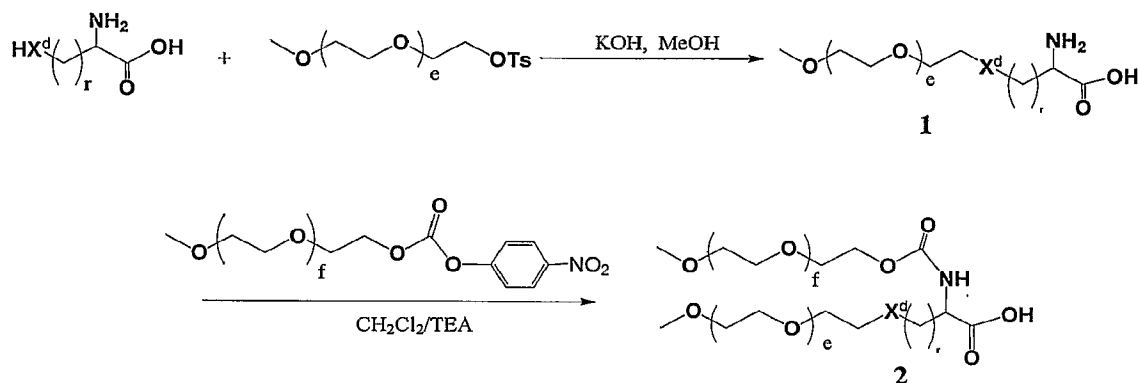


PEG molecules that are activated with these and other species and methods of making the activated PEGs are set forth in WO 04/083259.

**[0238]** Those of skill in the art will appreciate that one or more of the m-PEG arms of the branched polymers shown above can be replaced by a PEG moiety with a different terminus, e.g., OH, COOH, NH<sub>2</sub>, C<sub>2</sub>-C<sub>10</sub>-alkyl, etc. Moreover, the structures above are readily modified by inserting alkyl linkers (or removing carbon atoms) between the  $\alpha$ -carbon atom and the functional group of the amino acid side chain. Thus, “homo” derivatives and higher

homologues, as well as lower homologues are within the scope of cores for branched PEGs of use in the present invention.

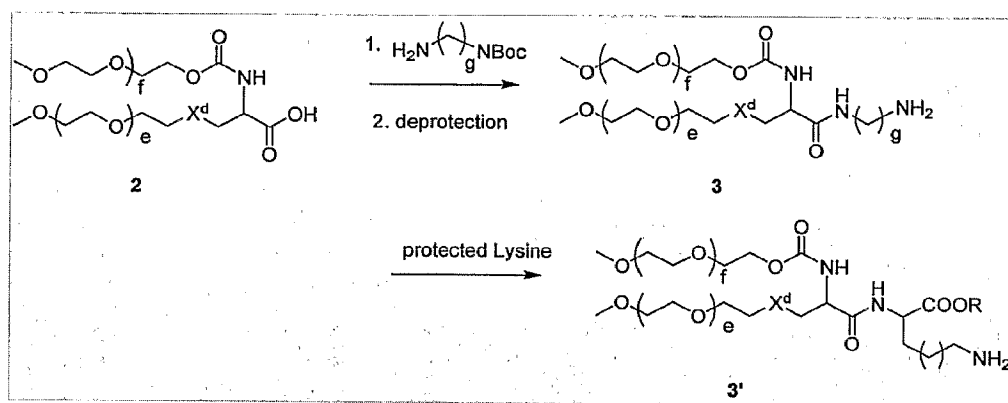
[0239] The branched PEG species set forth herein are readily prepared by methods such as that set forth in the scheme below:



in which  $\text{X}^d$  is O or S and  $r$  is an integer from 1 to 5. The indices  $e$  and  $f$  are independently selected integers from 1 to 2500. In an exemplary embodiment, one or both of these indices are selected such that the polymer is about 1 kDa, 2 kDa, 5 kDa, 10 kDa, 15 kDa, 20 kDa, 25 kDa, 30 kDa, 35 kDa, 40 kDa, 45 kDa, 50 kDa, 55 kDa, 60 kDa, 65 kDa, 70 kDa, 75 kDa or 80 kDa in molecular weight.

[0240] Thus, according to this scheme, a natural or unnatural amino acid is contacted with an activated m-PEG derivative, in this case the tosylate, forming **1** by alkylating the side-chain heteroatom  $\text{X}^d$ . The mono-functionalized m-PEG amino acid is submitted to N-acylation conditions with a reactive m-PEG derivative, thereby assembling branched m-PEG **2**. As one of skill will appreciate, the tosylate leaving group can be replaced with any suitable leaving group, e.g., halogen, mesylate, triflate, etc. Similarly, the reactive carbonate utilized to acylate the amine can be replaced with an active ester, e.g., N-hydroxysuccinimide, etc., or the acid can be activated *in situ* using a dehydrating agent such as dicyclohexylcarbodiimide, carbonyldiimidazole, etc.

[0241] In other exemplary embodiments, the urea moiety is replaced by a group such as an amide.



## II. E. Homodisperse Peptide Conjugate Compositions of Matter

**[0242]** In addition to providing peptide conjugates that are formed through a chemically or enzymatically added glycosyl linking group, the present invention provides compositions of matter comprising peptide conjugates that are highly homogenous in their substitution patterns. Using the methods of the invention, it is possible to form peptide conjugates in which substantial proportion of the glycosyl linking groups and glycosyl moieties across a population of peptide conjugates are attached to a structurally identical amino acid or glycosyl residue. Thus, in another aspect, the invention provides a peptide conjugate having a population of water-soluble polymer moieties, which are covalently bound to the peptide through a glycosyl linking group, e.g., a modified saccharyl fragment. In an exemplary peptide conjugate of the invention, essentially each member of the water soluble polymer population is bound via the modified saccharyl fragment to a glycosyl residue of the peptide, and each glycosyl residue of the peptide to which the modified saccharyl fragment is attached has the same structure.

**[0243]** The present invention also provides conjugates analogous to those described above in which the peptide is conjugated to a modifying group, e.g. therapeutic moiety, diagnostic moiety, targeting moiety, toxin moiety or the like via a glycosyl linking group such as a modified saccharyl fragment. Each of the above-recited modifying groups can be a small molecule, natural polymer (e.g., polypeptide) or synthetic polymer. When the modifying group is attached to a sialic acid, it is generally preferred that the modifying group is substantially non-fluorescent.

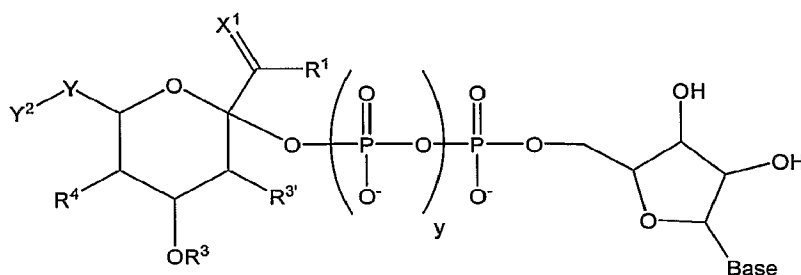
**[0244]** In an exemplary embodiment, the peptides of the invention include at least one O-linked or N-linked glycosylation site, which is glycosylated with a modified sugar that includes a polymeric modifying group, e.g., a PEG moiety. In an exemplary embodiment, the

PEG is covalently attached to the peptide via an intact glycosyl linking group such as a modified saccharyl fragment, or via a non-glycosyl linker, e.g., substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl. The glycosyl linking group is covalently attached to either an amino acid residue or a glycosyl residue of the peptide. Alternatively, the glycosyl linking group is attached to one or more glycosyl units of a glycopeptide. The invention also provides conjugates in which a glycosyl linking group is attached to both an amino acid residue and a glycosyl residue.

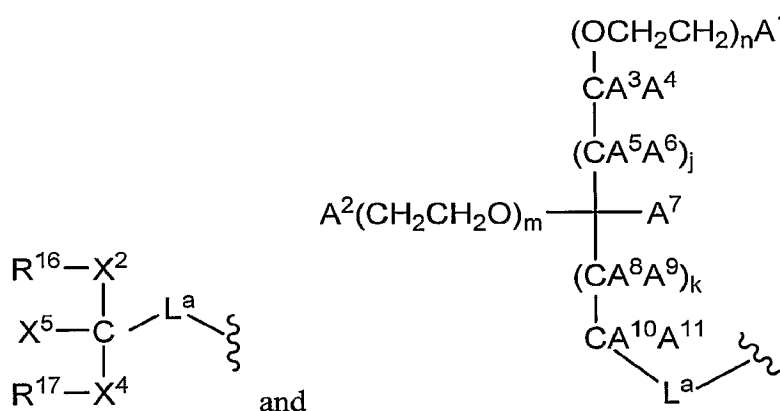
## II. F. Nucleotide Sugars

[0245] In another aspect of the invention, the invention also provides sugar nucleotides.

10 Exemplary species according to this embodiment include:

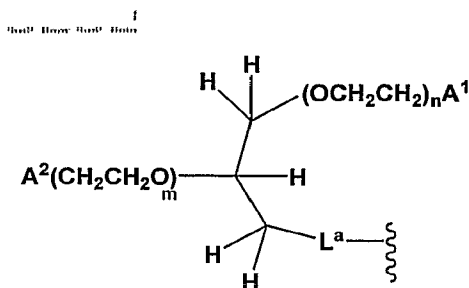


in which the index  $y$  is an integer selected from 0, 1 and 2. Base is a nucleic acid base, such as adenine, thymine, guanine, cytidine and uridine.  $Y$ ,  $X^1$ ,  $Y^2$ ,  $R^1$ ,  $R^3$  and  $R^4$  are as described above. In an exemplary embodiment,  $Y^2$  or  $L^a-(R^{6a})_w$  is a member selected from



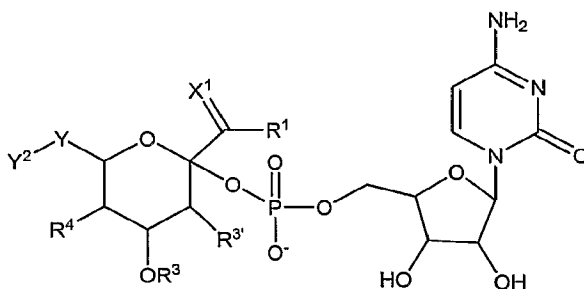
in which the variables are as described above.

[0246] In an exemplary embodiment,  $Y^2$  or  $L^a-(R^{6a})_w$  has a structure according to the following formula:



In an exemplary embodiment,  $A^1$  and  $A^2$  are each  $-\text{OCH}_3$ .

[0247] In another exemplary embodiment, the nucleotide sugar has a structure according to the following formula:



5

## The Methods

[0248] In addition to the compositions discussed above, the present invention provides methods for preparing modified saccharyl fragments and glyco-conjugates incorporating these fragments. Exemplary methods include synthesizing a modified peptide or lipid using a modified saccharyl fragment, *e.g.*, modified-galactose, -fucose, and -sialic acid. When a modified sialic acid is used, either a sialyltransferase or a trans-sialidase (for  $\alpha$ 2,3-linked sialic acid only) can be used to transfer the modified fragment onto the acceptor moiety of the substrate.

[0249] The method of the invention includes transferring a modified saccharyl fragment from an activated modified saccharyl fragment onto an acceptor moiety of a substrate. Exemplary substrates include peptides and lipids of therapeutic relevance. Exemplary acceptor moieties include amino acid residues, aglycone residues and glycosyl moieties directly or indirectly bound to an amino acid or aglycone residue.

[0250] For clarity of illustration, the invention is illustrated with reference to a conjugate formed between a (glyco)peptide a modified saccharyl fragment that is transferred to an acceptor moiety on the (glyco)peptide from an activated modified saccharyl fragment that includes a water-soluble polymer. Those of skill will appreciate that the invention equally

encompasses methods of forming conjugates of (glyco)lipids with saccharyl fragments modified with water-soluble polymers, and forming conjugates between (glyco)peptides and (glyco)lipids and saccharyl fragments bearing modifying groups other than water-soluble polymers.

5    **[0251]** In exemplary embodiments, the conjugate is formed between a water-soluble polymer, a therapeutic moiety, targeting moiety or a biomolecule, and a glycosylated peptide. The polymer, therapeutic moiety or biomolecule is conjugated to the peptide via a glycosyl linking group, which is interposed between, and covalently linked to, both the peptide (directly or through an intervening glycosyl linker) and the modifying group (*e.g.*, water-  
10    soluble polymer). The glycosyl linking group includes a modified saccharyl fragment. The method includes contacting the glycopeptide with an activated modified saccharyl fragment and an enzyme for which the activated modified saccharyl fragment is a substrate. The components of the reaction mixture are combined under conditions appropriate to enzymatically transfer the modified saccharyl fragment from the activated modified saccharyl  
15    fragment to an acceptor moiety on the glycopeptide, thereby preparing the conjugate.

**[0252]** The acceptor peptide is typically synthesized *de novo*, or recombinantly expressed in a prokaryotic cell (*e.g.*, bacterial cell, such as *E. coli*) or in a eukaryotic cell such as a mammalian, yeast, insect, fungal or plant cell. The peptide can be either a full-length protein or a fragment. Moreover, the peptide can be a wild type or mutated peptide. In an exemplary  
20    embodiment, the peptide includes a mutation that adds one or more N- or O-linked glycosylation sites to the peptide sequence.

**[0253]** The method of the invention also provides for modification of incompletely glycosylated peptides that are produced recombinantly. Many recombinantly produced glycoproteins are incompletely glycosylated, exposing carbohydrate residues that may have  
25    undesirable properties, *e.g.*, immunogenicity, recognition by the RES. The incomplete glycosyl residue can be masked using a water-soluble polymer.

**[0254]** Exemplary peptides that can be modified using the methods of the invention are set forth in **FIG.1**.

**[0255]** Peptides modified by the methods of the invention can be synthetic or wild-type  
30    peptides or they can be mutated peptides, produced by methods known in the art, such as site-directed mutagenesis. Glycosylation of peptides is typically either N-linked or O-linked. An



exemplary N-linkage is the attachment of the modified saccharyl fragment to the side chain of an asparagine residue. The tripeptide sequences asparagine-X-serine and asparagine-X-threonine, where X is any amino acid except proline, are the recognition sequences for enzymatic attachment of a carbohydrate moiety to the asparagine side chain. Thus, the presence of either of these tripeptide sequences in a polypeptide creates a potential glycosylation site. O-linked glycosylation refers to the attachment of one sugar (*e.g.*, N-acetylgalactosamine, galactose, mannose, GlcNAc, glucose, fucose or xylose) to the hydroxy side chain of a hydroxyamino acid, preferably serine or threonine, although unusual or non-natural amino acids, *e.g.*, 5-hydroxyproline or 5-hydroxylysine may also be used.

[0256] Moreover, in addition to peptides, the methods of the present invention can be practiced with other biological structures (*e.g.*, glycolipids, lipids, sphingoids, ceramides, whole cells, and the like. In general, the only limitation on the substrate structure is that it includes a glycosylation site).

[0257] For substrates lacking a glycosylation site, or for which it is desired to add a further glycosylation site, reliable methods are known in the art. For example, addition of glycosylation sites to a peptide, or other structure, is conveniently accomplished by altering the amino acid sequence such that it contains the desired glycosylation site. The addition may be made by mutation or by full chemical synthesis of the peptide. The peptide amino acid sequence is preferably altered through changes at the DNA level, particularly by mutating the DNA encoding the peptide at preselected bases such that codons are generated that will translate into the desired amino acids. The DNA mutation(s) are preferably made using methods known in the art. Both O-linked and N-linked glycosylation sites can be engineered into a peptide.

[0258] In an exemplary embodiment, the glycosylation site is added by shuffling polynucleotides. Polynucleotides encoding a candidate peptide can be modulated with DNA shuffling protocols. DNA shuffling is a process of recursive recombination and mutation, performed by random fragmentation of a pool of related genes, followed by reassembly of the fragments by a polymerase chain reaction-like process. *See, e.g.*, Stemmer, *Proc. Natl. Acad. Sci. USA* **91**: 10747-10751 (1994); Stemmer, *Nature* **370**: 389-391 (1994); and U.S. Patent Nos. 5,605,793, 5,837,458, 5,830,721 and 5,811,238.

[0259] The present invention also provides means of adding (or removing) one or more selected glycosyl residues to a peptide, after which a modified saccharyl fragment is

conjugated to at least one of the selected glycosyl residues of the peptide. The present embodiment is useful, for example, when it is desired to conjugate the modified saccharyl fragment to a selected glycosyl residue that is either not present on a peptide or is not present in a desired amount. Thus, prior to coupling a modified saccharyl fragment to a peptide, the selected glycosyl residue is conjugated to the peptide by enzymatic or chemical coupling. In another embodiment, the glycosylation pattern of a glycopeptide is altered prior to the conjugation of the modified saccharyl fragment by the removal of a carbohydrate residue from the glycopeptide. See, for example WO 98/31826.

[0260] Addition or removal of any carbohydrate moiety present on the glycopeptide is accomplished either chemically or enzymatically. Chemical deglycosylation is preferably brought about by exposure of the polypeptide variant to the compound trifluoromethanesulfonic acid, or an equivalent compound. This treatment results in the cleavage of most or all sugars except the linking sugar (N-acetylglucosamine or N-acetylgalactosamine), while leaving the peptide intact. Chemical deglycosylation is described by Hakimuddin *et al.*, *Arch. Biochem. Biophys.* **259**: 52 (1987) and by Edge *et al.*, *Anal. Biochem.* **118**: 131 (1981). Enzymatic cleavage of carbohydrate moieties on polypeptide variants can be achieved by the use of a variety of endo- and exo-glycosidases as described by Thotakura *et al.*, *Meth. Enzymol.* **138**: 350 (1987).

[0261] Chemical addition of glycosyl moieties is carried out by any art-recognized method. Enzymatic addition of sugar moieties is preferably achieved using a modification of the methods set forth herein, substituting native glycosyl units for the modified saccharyl fragments used in the invention. Other methods of adding sugar moieties are disclosed in U.S. Patent No. 5,876,980, 6,030,815, 5,728,554, and 5,922,577.

[0262] Exemplary attachment points for selected glycosyl residue include, but are not limited to: (a) consensus sites for N-linked glycosylation, and sites for O-linked glycosylation; (b) terminal glycosyl moieties that are acceptors for a glycosyltransferase; (c) arginine, asparagine and histidine; (d) free carboxyl groups; (e) free sulfhydryl groups such as those of cysteine; (f) free hydroxyl groups such as those of serine, threonine, or hydroxyproline; (g) aromatic residues such as those of phenylalanine, tyrosine, or tryptophan; or (h) the amide group of glutamine. Exemplary methods of use in the present invention are described in WO 87/05330 published Sep. 11, 1987, and in Aplin and Wriston, *CRC CRIT. REV. BIOCHEM.*, pp. 259-306 (1981).

[0263] In one embodiment, the invention provides a method for linking two or more peptides through a linking group. The linking group is of any useful structure and may be selected from straight- and branched-chain structures. Preferably, each terminus of the linker, which is attached to a peptide, includes a modified saccharyl fragment.

5 [0264] In an exemplary method of the invention, two peptides are linked together via a linker moiety that includes a polymeric (e.g., PEG linker). The focus on a PEG linker that includes two glycosyl groups is for purposes of clarity and should not be interpreted as limiting the identity of linker arms of use in this embodiment of the invention. In an example of this embodiment, diamino-PEG is converted to a bifunctional linking group by reaction  
10 with two saccharyl fragments, e.g., sialic acid aldehyde. The bifunctional linking group is then enzymatically coupled to each peptide. As will be appreciated by those of skill in the art, the saccharyl fragments attached to the PEG moiety can be the same or different.

[0265] Exemplary peptides with which the present invention can be practiced, methods of adding or removing glycosylation sites, and adding or removing glycosyl structures or  
15 substructures are described in detail in WO03/031464 and related U.S. and PCT applications.

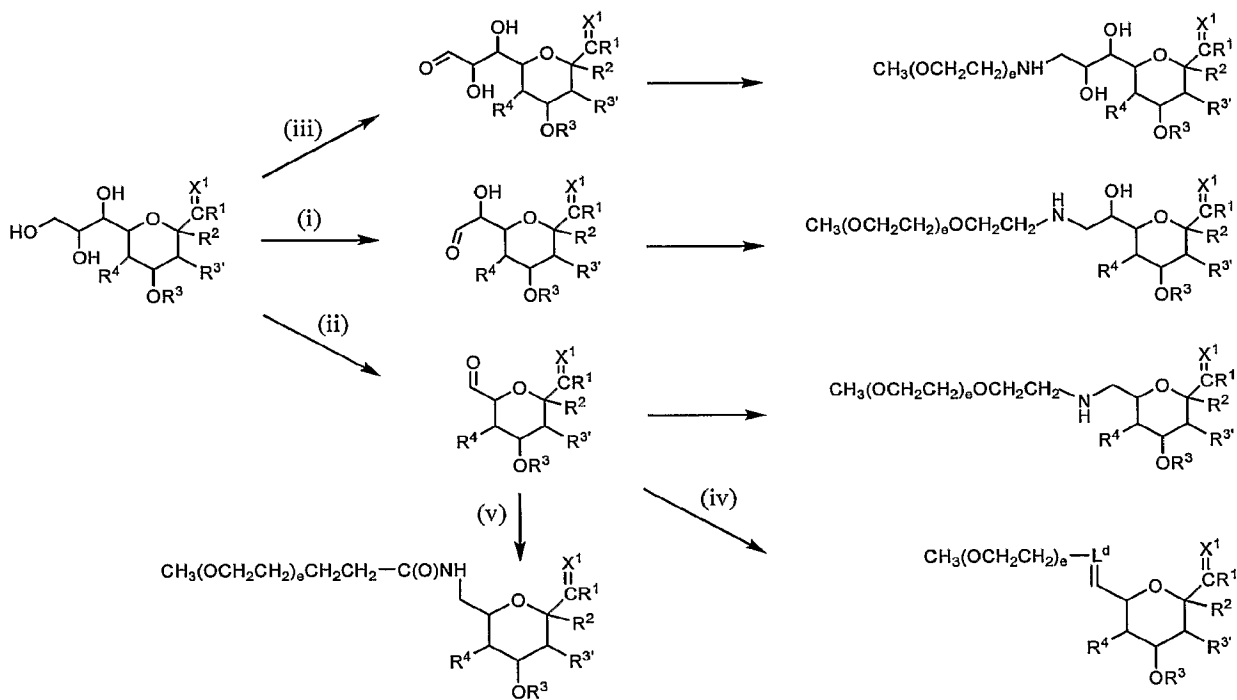
#### Preparation of Modified Saccharyl Fragments

[0266] In general, the saccharyl fragment and the modifying group are linked together through the use of reactive groups, which are typically transformed by the linking process into a new organic functional group or unreactive species. The reactive group on the  
20 saccharyl fragment is generally formed through a degradative process, e.g., oxidation. In the present invention, the modified saccharyl fragment is generally made by combining an amino analogue of the modifying group with an aldehyde or ketone moiety generated by oxidation of a saccharyl hydroxyl moiety.

[0267] In an exemplary embodiment, the method provides for forming a covalent conjugate  
25 between a modified saccharyl fragment and a glycosylated or non-glycosylated peptide. The method includes enzymatically transferring the modified saccharyl fragment from an activated modified saccharyl fragment to an acceptor moiety on the peptide. In another exemplary embodiment, the modified saccharyl fragment is covalently attached to a glycosyl residue that is covalently attached to the peptide. In another exemplary embodiment, the  
30 modified saccharyl fragment is covalently attached to an amino acid residue of the peptide. In another exemplary embodiment, the enzyme is a glycosyltransferase which is a member

selected from sialyltransferases, trans-sialidases, galactosyltransferases, glucosyltransferases, GalNAc transferase, GlcNAc transferase, fucosyltransferases, and mannosyltransferases. In another exemplary embodiment, the glycosyltransferase is recombinant. In another exemplary embodiment, the method is performed in a cell-free environment.

- 5 [0268] Methods for converting saccharyl hydroxyl moieties into carbonyl-containing compounds are well known in the art. As exemplified by the selective oxidation of the side chain of sialic acid, conditions are generally available for preparing an oxidized saccharyl precursor in a controlled and reproducible fashion.



- 10 [0269] For example, in the scheme above, selective oxidation of the primary hydroxyl of the sialic acid side chain, followed by reductive amination with m-PEG-NH<sub>2</sub> provides the corresponding saccharyl PEG-amine fragment according to route (iii).

- [0270] Further, mild periodate oxidation (e.g., 1 mM sodium metaperiodate, 0 °C), according to route (i), produces a sialic acid fragment that is incompletely oxidized relative to the fragment resulting from the harsher oxidation conditions of route (ii). The aldehyde is coupled with a modifying group, e.g., amino-m-PEG, under reducing conditions, thereby forming an exemplary sialic acid fragment-m-PEG conjugate.
- 15

[0271] As shown in route (iv), the oxidized sialic acid can also be reacted with a Wittig, Grignard or lithium reagent to form a species in which the water-soluble polymer and the saccharyl fragment are conjugated through a linker group,  $L^d$ . The alkene moiety can be reduced using art-recognized conditions, forming a species in which  $L^d$  is linked to the remainder of the saccharyl fragment through a saturated C-C bond. Exemplary linkers include substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl moieties.

[0272] Route (v) exemplifies a scheme in which the aldehyde is reductively aminated with ammonia and the resulting amine is acylated with an active m-PEG derivative, e.g., an active ester.

[0273] Those of skill in the art will readily appreciate that both routes (iv) and (v) can be practiced with any of the side chain oxidized sialic acid fragments set forth in the scheme.

[0274] In addition to the species described above,  $R^1$ - $R^4$  can also represent or include protecting groups or protected groups. Those of skill in the art understand how to protect a particular functional group such that it does not interfere with a chosen set of reaction conditions. For examples of useful protecting groups, *see*, for example, Greene *et al.*, PROTECTIVE GROUPS IN ORGANIC SYNTHESIS, John Wiley & Sons, New York, 1991.

[0275] Although exemplified above by reference to the use of an amine analogue of the modifying group, it is understood that the aldehyde or ketone group of the saccharide is readily modified by via formation of carbonyl derivatives such as, for example, imines, hydrazones, semicarbazones or oximes, or via such mechanisms as Grignard addition or alkyllithium addition. Accordingly, the present invention encompasses modified saccharyl fragments, linking groups and conjugates that include one or more of these derivatives, and is not limited to a particular saccharyl fragment or method of forming the fragment.

[0276] Exemplary moieties attached to the conjugates disclosed herein include, but are not limited to, PEG derivatives (e.g., acyl-PEG, acyl-alkyl-PEG, alkyl-acyl-PEG carbamoyl-PEG, aryl-PEG), PPG derivatives (e.g., acyl-PPG, acyl-alkyl-PPG, alkyl-acyl-PPG carbamoyl-PPG, aryl-PPG), therapeutic moieties, diagnostic moieties, mannose-6-phosphate, heparin, heparan,  $SLe_x$ , mannose, mannose-6-phosphate, Sialyl Lewis X, FGF, VFGF, proteins, chondroitin, keratan, dermatan, albumin, integrins, antennary oligosaccharides, peptides and the like. Methods of conjugating the various modifying groups to a saccharide



amide bond such as carbodiimides, ethylchloroformate, Woodward's reagent K (2-ethyl-5-phenylisoxazolium-3'-sulfonate), and carbonyldiimidazole. In addition to these chemical reagents, the enzyme transglutaminase (glutamyl-peptide  $\gamma$ -glutamyltransferase; EC 2.3.2.13) may be used as zero-length crosslinking reagent. This enzyme catalyzes acyl transfer reactions at carboxamide groups of protein-bound glutamyl residues, usually with a primary amino group as substrate. Preferred homo- and hetero-bifunctional reagents contain two identical or two dissimilar sites, respectively, which may be reactive for amino, sulfhydryl, guanidino, indole, or nonspecific groups.

[0279] An exemplary cross-linking moiety includes a reactive functional group that reacts with the saccharyl ketone or aldehyde moiety (e.g., amine, hydrazine, etc.). The reactive functional group is tethered to a second reactive functional group that reacts with a moiety on the modifying group, forming a linker covalently bonded to both the saccharyl fragment and the modifying group.

[0280] Exemplary cross-linking groups of use in the present invention are set forth in WO03/031464 and related U.S. and PCT applications.

#### Conjugation of Modified Saccharyl Fragments to Peptides

[0281] The modified saccharyl fragments are conjugated to a glycosylated or non-glycosylated peptide using an appropriate enzyme to mediate the conjugation. Preferably, the concentrations of the modified donor sugar(s), enzyme(s) and acceptor peptide(s) are selected such that glycosylation proceeds until the acceptor is consumed. The considerations discussed below, while set forth in the context of a sialyltransferase, are generally applicable to other glycosyltransferase reactions.

[0282] A number of methods of using glycosyltransferases to synthesize desired oligosaccharide structures are known and are generally applicable to the instant invention. Exemplary methods are described, for instance, WO 96/32491, Ito *et al.*, *Pure Appl. Chem.* **65**: 753 (1993), and U.S. Pat. Nos. 5,352,670, 5,374,541, and 5,545,553.

[0283] The present invention is practiced using a single glycosyltransferase or a combination of glycosyltransferases. For example, one can use a combination of a sialyltransferase and a galactosyltransferase. In those embodiments using more than one enzyme, the enzymes and substrates are preferably combined in an initial reaction mixture, or the enzymes and reagents for a second enzymatic reaction are added to the reaction medium

once the first enzymatic reaction is complete or nearly complete. By conducting two enzymatic reactions in sequence in a single vessel, overall yields are improved over procedures in which an intermediate species is isolated. Moreover, cleanup and disposal of extra solvents and by-products is reduced.

5 [0284] In a preferred embodiment, each of the first and second enzyme is a glycosyltransferase. In another preferred embodiment, one enzyme is an endoglycosidase. In an additional preferred embodiment, more than two enzymes are used to assemble the modified glycoprotein of the invention. The enzymes are used to alter a saccharide structure on the peptide at any point either before or after the addition of the modified saccharyl  
10 fragment to the peptide.

[0285] In another preferred embodiment, each of the enzymes utilized to produce a conjugate of the invention are present in a catalytic amount. The catalytic amount of a particular enzyme varies according to the concentration of that enzyme's substrate as well as to reaction conditions such as temperature, time and pH value. Means for determining the  
15 catalytic amount for a given enzyme under preselected substrate concentrations and reaction conditions are well known to those of skill in the art.

[0286] The temperature at which an above process is carried out can range from just above freezing to the temperature at which the most sensitive enzyme denatures. Preferred temperature ranges are about 0 °C to about 45 °C, and more preferably about 20 °C to about  
20 30 °C. In another exemplary embodiment, one or more components of the present method are conducted at an elevated temperature using a thermophilic enzyme.

[0287] The reaction mixture is maintained for a period of time sufficient for the acceptor to be glycosylated, thereby forming the desired conjugate. Some of the conjugate can often be detected after a few hours, with recoverable amounts usually being obtained within 24 hours  
25 or less. Those of skill in the art understand that the rate of reaction is dependent on a number of variable factors (*e.g.*, enzyme concentration, donor concentration, acceptor concentration, temperature, solvent volume), which are optimized for a selected system.

[0288] The present invention also provides for the industrial-scale production of modified peptides.

30 [0289] In the discussion that follows, the invention is exemplified by the conjugation of modified sialic acid fragment to a glycosylated peptide. The exemplary modified sialic acid



fragment is labeled with PEG. The focus of the following discussion on the use of PEG-modified sialic acid fragments and glycosylated peptides is for clarity of illustration and is not intended to imply that the invention is limited to the conjugation of these two partners. One of skill understands that the discussion is generally applicable to the additions of modified glycosyl fragments other than sialic acid fragments. Moreover, the discussion is equally applicable to the modification of a saccharyl fragment with agents other than PEG including other water-soluble polymers, therapeutic moieties, and biomolecules.

[0290] An enzymatic approach can be used for the selective introduction of PEGylated or PPGylated carbohydrates onto a peptide or glycopeptide. The method utilizes modified saccharyl fragments containing PEG, PPG, or a masked reactive functional group, and is combined with the appropriate glycosyltransferase or glycosynthase. By selecting the glycosyltransferase that will make the desired carbohydrate linkage and utilizing the modified saccharyl fragment as the donor substrate, the PEG or PPG can be introduced directly onto the peptide backbone, onto existing sugar residues of a glycopeptide or onto sugar residues that have been added to a peptide.

[0291] An acceptor for the sialyltransferase is present on the peptide to be modified by the methods of the present invention either as a naturally occurring structure or one placed there recombinantly, enzymatically or chemically. Suitable acceptors, include, for example, galactosyl acceptors such as GalNAc, Gal $\beta$ 1,4GlcNAc, Gal $\beta$ 1,4GalNAc, Gal $\beta$ 1,3GalNAc, lacto-N-tetraose, Gal $\beta$ 1,3GlcNAc, Gal $\beta$ 1,3Ara, Gal $\beta$ 1,6GlcNAc, Gal $\beta$ 1,4Glc (lactose), and other acceptors known to those of skill in the art (*see, e.g., Paulson et al., J. Biol. Chem.* **253**: 5617-5624 (1978)).

[0292] In one embodiment, an acceptor for the sialyltransferase is present on the glycopeptide to be modified upon *in vivo* synthesis of the glycopeptide. Such glycopeptides can be sialylated using the claimed methods without prior modification of the glycosylation pattern of the glycopeptide. Alternatively, the methods of the invention can be used to sialylate a peptide that does not include a suitable acceptor; one first modifies the peptide to include an acceptor by methods known to those of skill in the art. In an exemplary embodiment, a GalNAc residue is added by the action of a GalNAc transferase.

[0293] In an exemplary embodiment, an acceptor for a modified sialic acid fragment is assembled by attaching a galactose residue to an appropriate acceptor linked to the peptide, e.g., a GlcNAc. The method includes incubating the peptide to be modified with a reaction

... ..  
mixture that contains a suitable amount of a galactosyltransferase (*e.g.*, gal $\beta$ 1,3 or gal $\beta$ 1,4), and a suitable galactosyl donor (*e.g.*, UDP-galactose). The reaction is allowed to proceed substantially to completion or, alternatively, the reaction is terminated when a preselected amount of the galactose residue is added. Other methods of assembling a selected saccharide  
5 acceptor will be apparent to those of skill in the art.

[0294] In yet another embodiment, glycopeptide-linked oligosaccharides are first “trimmed,” either in whole or in part, to expose either an acceptor for the sialyltransferase or a moiety to which one or more appropriate residues can be added to obtain a suitable acceptor. Enzymes such as glycosyltransferases and endoglycosidases (*see*, for example U.S.  
10 Patent No. 5,716,812) are useful for the attaching and trimming reactions.

[0295] In the discussion that follows, the method of the invention is exemplified by the use of modified saccharyl fragments having a water-soluble polymer attached thereto. The focus of the discussion is for clarity of illustration. Those of skill will appreciate that the discussion is equally relevant to those embodiments in which the modified saccharyl fragment bears a  
15 therapeutic moiety, biomolecule or the like.

[0296] In another exemplary embodiment, a water-soluble polymer is added to one or both of the terminal mannose residues of the biantennary structure via a modified saccharyl fragment having a galactose residue, which is conjugated to a GlcNAc residue added onto the terminal mannose residues. Alternatively, an unmodified Gal can be added to one or both  
20 terminal GlcNAc residues.

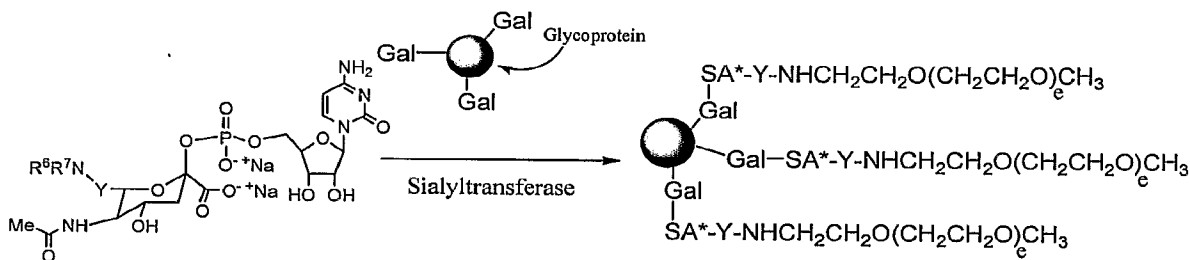
[0297] In yet a further example, a water-soluble polymer is added onto a Gal residue using a modified sialic acid fragment.

[0298] The Examples set forth above provide an illustration of the power of the methods set forth herein. Using the methods of the invention, it is possible to “trim back” and build up  
25 a carbohydrate residue of substantially any desired structure. The modified saccharyl fragment can be added to the termini of the carbohydrate moiety as set forth above, or it can be intermediate between the peptide core and the terminus of the carbohydrate.

[0299] In an exemplary embodiment, an existing sialic acid is removed from a glycopeptide using a sialidase, thereby unmasking all or most of the underlying galactosyl residues.  
30 Alternatively, a peptide or glycopeptide is labeled with galactose residues, or an oligosaccharide residue that terminates in a galactose unit. Following the exposure of, or

addition of, the galactose residues, an appropriate sialyltransferase is used to add a modified sialic acid. The approach is summarized in Scheme 2.

**Scheme 2**



5 In which SA\* is saccharyl fragment and Y is as described above (Formula I).

[0300] In an alternative embodiment, the modified saccharyl fragment is added directly to the peptide backbone using a glycosyltransferase known to transfer sugar residues to the peptide backbone. Use of this approach allows the direct addition of modified saccharyl fragments onto peptides that lack any carbohydrates or, alternatively, onto existing glycopeptides. In both cases, the addition of the modified saccharyl fragment occurs at specific positions on the peptide backbone as defined by the substrate specificity of the glycosyltransferase and not in a random manner as occurs during modification of a protein's peptide backbone using chemical methods. An array of agents can be introduced into proteins or glycopeptides that lack the glycosyltransferase substrate peptide sequence by engineering the appropriate amino acid sequence into the polypeptide chain.

[0301] In each of the exemplary embodiments set forth above, one or more additional chemical or enzymatic modification steps can be utilized following the conjugation of the modified saccharyl fragment to the peptide. In an exemplary embodiment, an enzyme (*e.g.*, fucosyltransferase) is used to append a glycosyl unit (*e.g.*, fucose) onto the terminal modified saccharyl fragment attached to the peptide. In another example, an enzymatic reaction is utilized to "cap" sites to which the modified saccharyl fragment failed to conjugate. Alternatively, a chemical reaction is utilized to alter the structure of the conjugated modified saccharyl fragment. For example, the conjugated modified saccharyl fragment is reacted with agents that stabilize or destabilize its linkage with the peptide component to which the modified saccharyl fragment is attached. In another example, a component of the modified saccharyl fragment is deprotected following its conjugation to the peptide. One of skill will appreciate that there is an array of enzymatic and chemical procedures that are useful in the

methods of the invention at a stage after the modified saccharyl fragment is conjugated to the peptide. Further elaboration of the modified saccharyl fragment-peptide conjugate is within the scope of the invention.

[0302] In another exemplary embodiment, the invention provides a composition for forming a conjugate between a peptide and a modified saccharyl fragment. This composition includes a mixture of an activated modified saccharyl fragment, an enzyme for which the activated modified saccharyl fragment is a substrate, and a peptide acceptor substrate, wherein the modified saccharyl fragment is covalently attached a member selected from water-soluble polymers, therapeutic moieties and biomolecules.

## 10 *Enzymes*

[0303] General methods of remodeling peptides and lipids using enzymes that transfer a sugar donor to an acceptor are discussed in detail in DeFrees, WO 03/031464 A2, published April 17, 2003. A brief summary of selected enzymes of use in the present method is set forth below.

## 15 *Glycosyltransferases*

[0304] Glycosyltransferases catalyze the addition of activated sugars (donor NDP-sugars), in a step-wise fashion, to a protein, glycopeptide, lipid or glycolipid or to the non-reducing end of a growing oligosaccharide. N-linked glycopeptides are synthesized via a transferase and a lipid-linked oligosaccharide donor Dol-PP-NAG<sub>2</sub>Glc<sub>3</sub>Man<sub>9</sub> in an en block transfer followed by trimming of the core. In this case the nature of the "core" saccharide is somewhat different from subsequent attachments. A very large number of glycosyltransferases are known in the art.

[0305] The glycosyltransferase to be used in the present invention may be any as long as it can utilize the modified saccharyl fragment as a sugar donor. Examples of such enzymes include Leloir pathway glycosyltransferase, such as galactosyltransferase, N-acetylglucosaminyltransferase, N-acetylgalactosaminyltransferase, fucosyltransferase, sialyltransferase, mannosyltransferase, xylosyltransferase, glucurononyltransferase and the like.

[0306] For enzymatic saccharide syntheses that involve glycosyltransferase reactions, glycosyltransferase can be cloned, or isolated from any source. Many cloned glycosyltransferases are known, as are their polynucleotide sequences. See, e.g., "The WWW

Guide To Cloned Glycosyltransferases,” Taniguchi et al., 2002, Handbook of Glycosyltransferases and Related Genes, Springer, Tokyo. Glycosyltransferase amino acid sequences and nucleotide sequences encoding glycosyltransferases from which the amino acid sequences can be deduced are also found in various publicly available databases, including GenBank, Swiss-Prot, EMBL, and others.

[0307] Glycosyltransferases that can be employed in the methods of the invention include, but are not limited to, galactosyltransferases, fucosyltransferases, glucosyltransferases, N-acetylgalactosaminyltransferases, N-acetylglucosaminyltransferases, glucuronyltransferases, sialyltransferases, mannosyltransferases, glucuronic acid transferases, galacturonic acid transferases, and oligosaccharyltransferases. Suitable glycosyltransferases include those obtained from eukaryotes, as well as from prokaryotes. The enzymes may be wild-type or mutant enzymes. Methods of preparing mutant glycosyltransferases and characterizing these species are known in the art.

#### Fucosyltransferases

[0308] In some embodiments, a glycosyltransferase used in the method of the invention is a fucosyltransferase. Fucosyltransferases are known to those of skill in the art. Exemplary fucosyltransferases include enzymes, which transfer L-fucose from GDP-fucose to a hydroxy position of an acceptor sugar. Fucosyltransferases that transfer non-nucleotide sugars to an acceptor are also of use in the present invention.

[0309] In some embodiments, the acceptor sugar is, for example, the GlcNAc in a Gal $\beta$ (1 $\rightarrow$ 3,4)GlcNAc $\beta$ - group in an oligosaccharide glycoside. Suitable fucosyltransferases for this reaction include the Gal $\beta$ (1 $\rightarrow$ 3,4)GlcNAc $\beta$ 1- $\alpha$ (1 $\rightarrow$ 3,4)fucosyltransferase (FTIII E.C. No. 2.4.1.65), which was first characterized from human milk (*see*, Palcic, *et al.*, *Carbohydrate Res.* **190**: 1-11 (1989); Prieels, *et al.*, *J. Biol. Chem.* **256**: 10456-10463 (1981); and Nunez, *et al.*, *Can. J. Chem.* **59**: 2086-2095 (1981)) and the Gal $\beta$ (1 $\rightarrow$ 4)GlcNAc $\beta$ - $\alpha$ fucosyltransferases (FTIV, FTV, FTVI) which are found in human serum. FTVII (E.C. No. 2.4.1.65), a sialyl  $\alpha$ (2 $\rightarrow$ 3)Gal $\beta$ ((1 $\rightarrow$ 3)GlcNAc $\beta$  fucosyltransferase, has also been characterized. A recombinant form of the Gal $\beta$ (1 $\rightarrow$ 3,4) GlcNAc $\beta$ - $\alpha$ (1 $\rightarrow$ 3,4)fucosyltransferase has also been characterized (*see*, Dumas, *et al.*, *Bioorg. Med. Letters* **1**: 425-428 (1991) and Kukowska-Latallo, *et al.*, *Genes and Development* **4**: 1288-1303 (1990)). Other exemplary fucosyltransferases include, for example,  $\alpha$ 1,2

fucosyltransferase (E.C. No. 2.4.1.69). Enzymatic fucosylation can be carried out by the methods described in Mollicone, *et al.*, *Eur. J. Biochem.* **191**: 169-176 (1990) or U.S. Patent No. 5,374,655. Cells that are used to produce a fucosyltransferase will also include an enzymatic system for synthesizing GDP-fucose.

#### 5 Galactosyltransferases

[0310] In another group of embodiments, the glycosyltransferase is a galactosyltransferase. Exemplary galactosyltransferases include  $\alpha(1,3)$  galactosyltransferases (E.C. No. 2.4.1.151, *see, e.g.*, Dabkowski *et al.*, *Transplant Proc.* **25**:2921 (1993) and Yamamoto *et al.* *Nature* **345**: 229-233 (1990), bovine (GenBank j04989, Joziassse *et al.*, *J. Biol. Chem.* **264**: 14290-14297 (1989)), murine (GenBank m26925; Larsen *et al.*, *Proc. Nat'l. Acad. Sci. USA* **86**: 8227-8231 (1989)), porcine (GenBank L36152; Strahan *et al.*, *Immunogenetics* **41**: 101-105 (1995)). Another suitable  $\alpha(1,3)$  galactosyltransferase is that which is involved in synthesis of the blood group B antigen (EC 2.4.1.37, Yamamoto *et al.*, *J. Biol. Chem.* **265**: 1146-1151 (1990) (human)). Yet a further exemplary galactosyltransferase is core Gal-T1.

15 [0311] Also suitable for use in the methods of the invention are  $\beta(1,4)$  galactosyltransferases, which include, for example, EC 2.4.1.90 (LacNAc synthetase) and EC 2.4.1.22 (lactose synthetase) (bovine (D'Agostaro *et al.*, *Eur. J. Biochem.* **183**: 211-217 (1989)), human (Masri *et al.*, *Biochem. Biophys. Res. Commun.* **157**: 657-663 (1988)), murine (Nakazawa *et al.*, *J. Biochem.* **104**: 165-168 (1988)), as well as E.C. 2.4.1.38 and the  
20 ceramide galactosyltransferase (EC 2.4.1.45, Stahl *et al.*, *J. Neurosci. Res.* **38**: 234-242 (1994)). Other suitable galactosyltransferases include, for example,  $\alpha(1,2)$  galactosyltransferases (from *e.g.*, *Schizosaccharomyces pombe*, Chapell *et al.*, *Mol. Biol. Cell* **5**: 519-528 (1994)).

#### Sialyltransferases

25 [0312] Sialyltransferases are another type of glycosyltransferase that is useful in the recombinant cells and reaction mixtures of the invention. Cells that produce recombinant sialyltransferases will also produce CMP-sialic acid, which is a sialic acid donor for sialyltransferases. Examples of sialyltransferases that are suitable for use in the present invention include ST3Gal III (*e.g.*, a rat or human ST3Gal III), ST3Gal IV, ST3Gal I, ST6Gal  
30 I, ST3Gal V, ST6Gal II, ST6GalNAc I, ST6GalNAc II, and ST6GalNAc III (the sialyltransferase nomenclature used herein is as described in Tsuji *et al.*, *Glycobiology* **6**: v-

xiv (1996)). An exemplary  $\alpha(2,3)$ sialyltransferase referred to as  $\alpha(2,3)$ sialyltransferase (EC 2.4.99.6) transfers sialic acid to the non-reducing terminal Gal of a Gal $\beta$ 1 $\rightarrow$ 3Glc disaccharide or glycoside. See, Van den Eijnden *et al.*, *J. Biol. Chem.* **256**: 3159 (1981), Weinstein *et al.*, *J. Biol. Chem.* **257**: 13845 (1982) and Wen *et al.*, *J. Biol. Chem.* **267**: 21011 (1992). Another  
5 exemplary  $\alpha 2,3$ -sialyltransferase (EC 2.4.99.4) transfers sialic acid to the non-reducing terminal Gal of the disaccharide or glycoside. see, Rearick *et al.*, *J. Biol. Chem.* **254**: 4444 (1979) and Gillespie *et al.*, *J. Biol. Chem.* **267**: 21004 (1992). Further exemplary enzymes include Gal- $\beta$ -1,4-GlcNAc  $\alpha$ -2,6 sialyltransferase (See, Kurosawa *et al.* *Eur. J. Biochem.* **219**: 375-381 (1994)).

10 **[0313]** A list of sialyltransferases of use in the invention are provided in **FIG.2**.

#### GalNAc transferases

**[0314]** N-acetylgalactosaminyltransferases are of use in practicing the present invention, particularly for binding a GalNAc moiety to an amino acid of the O-linked glycosylation site of the peptide. Suitable N-acetylgalactosaminyltransferases include, but are not limited to,  
15  $\alpha(1,3)$  N-acetylgalactosaminyltransferase,  $\beta(1,4)$  N-acetylgalactosaminyltransferases (Nagata *et al.*, *J. Biol. Chem.* **267**: 12082-12089 (1992) and Smith *et al.*, *J. Biol. Chem.* **269**: 15162 (1994)) and polypeptide N-acetylgalactosaminyltransferase (Homa *et al.*, *J. Biol. Chem.* **268**: 12609 (1993)). See also the work of W. Wakarchuk generally and U.S. Patent No. 6,723,545; and published U.S. Patent Application No. 2003/0180928; 2003/0157658;  
20 2003/0157657; and 2003/0157656.

**[0315]** Production of proteins such as the enzyme GalNAc T<sub>I-XX</sub> from cloned genes by genetic engineering is well known. See, eg., U.S. Pat. No. 4,761,371. One method involves collection of sufficient samples, then the amino acid sequence of the enzyme is determined by N-terminal sequencing. This information is then used to isolate a cDNA clone encoding a  
25 full-length (membrane bound) transferase which upon expression in the insect cell line Sf9 resulted in the synthesis of a fully active enzyme. The acceptor specificity of the enzyme is then determined using a semiquantitative analysis of the amino acids surrounding known glycosylation sites in 16 different proteins followed by in vitro glycosylation studies of synthetic peptides. This work has demonstrated that certain amino acid residues are  
30 overrepresented in glycosylated peptide segments and that residues in specific positions

surrounding glycosylated serine and threonine residues may have a more marked influence on acceptor efficiency than other amino acid moieties.

Cell-Bound Glycosyltransferases

[0316] In another embodiment, the enzymes utilized in the method of the invention are cell-bound glycosyltransferases. Although many soluble glycosyltransferases are known (see, for example, U.S. Pat. No. 5,032,519), glycosyltransferases are generally in membrane-bound form when associated with cells. Many of the membrane-bound enzymes studied thus far are considered to be intrinsic proteins; that is, they are not released from the membranes by sonication and require detergents for solubilization. Surface glycosyltransferases have been identified on the surfaces of vertebrate and invertebrate cells, and it has also been recognized that these surface transferases maintain catalytic activity under physiological conditions. However, the more recognized function of cell surface glycosyltransferases is for intercellular recognition (Roth, MOLECULAR APPROACHES to SUPRACELLULAR PHENOMENA, 1990).

[0317] Methods have been developed to alter the glycosyltransferases expressed by cells. For example, Larsen *et al.*, *Proc. Natl. Acad. Sci. USA* **86**: 8227-8231 (1989), report a genetic approach to isolate cloned cDNA sequences that determine expression of cell surface oligosaccharide structures and their cognate glycosyltransferases. A cDNA library generated from mRNA isolated from a murine cell line known to express UDP-galactose:β-D-galactosyl-1,4-N-acetyl-D-glucosaminide α-1,3-galactosyltransferase was transfected into COS-1 cells. The transfected cells were then cultured and assayed for α 1-3 galactosyltransferase activity.

[0318] Francisco *et al.*, *Proc. Natl. Acad. Sci. USA* **89**: 2713-2717 (1992), disclose a method of anchoring β-lactamase to the external surface of *Escherichia coli*. A tripartite fusion consisting of (i) a signal sequence of an outer membrane protein, (ii) a membrane-spanning section of an outer membrane protein, and (iii) a complete mature β-lactamase sequence is produced resulting in an active surface bound β-lactamase molecule. However, the Francisco method is limited only to procaryotic cell systems and as recognized by the authors, requires the complete tripartite fusion for proper functioning.



### Sulfotransferases

[0319] The invention also provides methods for producing peptides that include sulfated molecules, including, for example sulfated polysaccharides such as heparin, heparan sulfate, carragenen, and related compounds. Suitable sulfotransferases include, for example, chondroitin-6-sulphotransferase (chicken cDNA described by Fukuta *et al.*, *J. Biol. Chem.* **270**: 18575-18580 (1995); GenBank Accession No. D49915), glycosaminoglycan N-acetylglucosamine N-deacetylase/N-sulphotransferase 1 (Dixon *et al.*, *Genomics* **26**: 239-241 (1995); UL18918), and glycosaminoglycan N-acetylglucosamine N-deacetylase/N-sulphotransferase 2 (murine cDNA described in Orellana *et al.*, *J. Biol. Chem.* **269**: 2270-2276 (1994) and Eriksson *et al.*, *J. Biol. Chem.* **269**: 10438-10443 (1994); human cDNA described in GenBank Accession No. U2304).

### Glycosidases

[0320] This invention also encompasses the use of wild-type and mutant glycosidases. Mutant  $\beta$ -galactosidase enzymes have been demonstrated to catalyze the formation of disaccharides through the coupling of an  $\alpha$ -glycosyl fluoride to a galactosyl acceptor molecule. (Withers, U.S. Pat. No. 6,284,494; issued Sept. 4, 2001). Other glycosidases of use in this invention include, for example,  $\beta$ -glucosidases,  $\beta$ -galactosidases,  $\beta$ -mannosidases,  $\beta$ -acetyl glucosaminidases,  $\beta$ -N-acetyl galactosaminidases,  $\beta$ -xylosidases,  $\beta$ -fucosidases, cellulases, xylanases, galactanases, mannanases, hemicellulases, amylases, glucoamylases,  $\alpha$ -glucosidases,  $\alpha$ -galactosidases,  $\alpha$ -mannosidases,  $\alpha$ -N-acetyl glucosaminidases,  $\alpha$ -N-acetyl galactose-aminidases,  $\alpha$ -xylosidases,  $\alpha$ -fucosidases, and neuraminidases/sialidases.

### Immobilized Enzymes

[0321] The present invention also provides for the use of enzymes that are immobilized on a solid and/or soluble support. In an exemplary embodiment, there is provided a glycosyltransferase that is conjugated to a PEG via an intact glycosyl linker according to the methods of the invention. The PEG-linker-enzyme conjugate is optionally attached to solid support. The use of solid supported enzymes in the methods of the invention simplifies the work up of the reaction mixture and purification of the reaction product, and also enables the facile recovery of the enzyme. The glycosyltransferase conjugate is utilized in the methods of the invention. Other combinations of enzymes and supports will be apparent to those of skill in the art.

### ***Purification of Peptide Conjugates***

[0322] The products produced by the above processes can be used without purification.

However, it is usually preferred to recover the product. Standard, well-known techniques for recovery of modified peptides such as thin or thick layer chromatography, column

5 chromatography, ion exchange chromatography, or membrane filtration can be used. It is preferred to use membrane filtration, more preferably utilizing a reverse osmotic membrane, or one or more column chromatographic techniques for the recovery as is discussed

hereinafter and in the literature cited herein. For instance, membrane filtration wherein the membranes have molecular weight cutoff of about 3000 to about 10,000 can be used to

10 remove proteins such as glycosyl transferases. Nanofiltration or reverse osmosis can then be used to remove salts and/or purify the conjugates (*see, e.g.*, WO 98/15581). Nanofilter

membranes are a class of reverse osmosis membranes that pass monovalent salts but retain polyvalent salts and uncharged solutes larger than about 100 to about 2,000 Daltons,

depending upon the membrane used. Thus, in a typical application, conjugates prepared by

15 the methods of the present invention will be retained in the membrane and contaminating salts will pass through.

[0323] If the modified glycoprotein is produced intracellularly, as a first step, the particulate debris, either host cells or lysed fragments, is removed, for example, by

centrifugation or ultrafiltration; optionally, the protein may be concentrated with a

20 commercially available protein concentration filter, followed by separating the polypeptide variant from other impurities by one or more steps selected from immunoaffinity

chromatography, ion-exchange column fractionation (*e.g.*, on diethylaminoethyl (DEAE) or matrices containing carboxymethyl or sulfopropyl groups), chromatography on Blue-

Sepharose, CM Blue-Sepharose, MONO-Q, MONO-S, lentil lectin-Sepharose, WGA-

25 Sepharose, Con A-Sepharose, Ether Toyopearl, Butyl Toyopearl, Phenyl Toyopearl, or

protein A Sepharose, SDS-PAGE chromatography, silica chromatography,

chromatofocusing, reverse phase HPLC (*e.g.*, silica gel with appended aliphatic groups), gel

filtration using, *e.g.*, Sephadex molecular sieve or size-exclusion chromatography,

chromatography on columns that selectively bind the polypeptide, and ethanol or ammonium

30 sulfate precipitation.

[0324] Modified glycopeptides produced in culture are usually isolated by initial extraction from cells, enzymes, etc., followed by one or more concentration, salting-out, aqueous ion-

exchange, or size-exclusion chromatography steps. Additionally, the modified glycoprotein may be purified by affinity chromatography. Finally, HPLC may be employed for final purification steps.

[0325] A protease inhibitor, *e.g.*, methylsulfonylfluoride (PMSF) may be included in any of the foregoing steps to inhibit proteolysis and antibiotics may be included to prevent the growth of adventitious contaminants.

[0326] In another method, supernatants from systems that produce the modified glycopeptide of the invention are first concentrated using a commercially available protein concentration filter, for example, an Amicon or Millipore Pellicon ultrafiltration unit.

Following the concentration step, the concentrate may be applied to a suitable purification matrix. For example, a suitable affinity matrix may comprise a ligand for the peptide, a lectin or antibody molecule bound to a suitable support. Alternatively, an anion-exchange resin may be employed, for example, a matrix or substrate having pendant DEAE groups. Suitable matrices include acrylamide, agarose, dextran, cellulose, or other types commonly employed in protein purification. Alternatively, a cation-exchange step may be employed. Suitable cation exchangers include various insoluble matrices comprising sulfopropyl or carboxymethyl groups. Sulfopropyl groups are particularly preferred.

[0327] Finally, one or more RP-HPLC steps employing hydrophobic RP-HPLC media, *e.g.*, silica gel having pendant methyl or other aliphatic groups, may be employed to further purify a polypeptide variant composition. Some or all of the foregoing purification steps, in various combinations, can also be employed to provide a homogeneous modified glycoprotein.

[0328] The modified glycopeptide of the invention resulting from a large-scale fermentation may be purified by methods analogous to those disclosed by Urdal *et al.*, *J. Chromatog.* **296**: 171 (1984). This reference describes two sequential, RP-HPLC steps for purification of recombinant human IL-2 on a preparative HPLC column. Alternatively, techniques such as affinity chromatography may be utilized to purify the modified glycoprotein.

### Pharmaceutical Compositions

[0329] In another aspect, the invention provides a pharmaceutical composition. The pharmaceutical composition includes a pharmaceutically acceptable carrier and a conjugate between a glycosylated or non-glycosylated peptide and a modified saccharyl fragment which

is covalently linked to a water-soluble or –insoluble polymer, therapeutic moiety or biomolecule. The polymer, therapeutic moiety or biomolecule is conjugated to the peptide via an intact glycosyl linking group interposed between and covalently linked to both the peptide and the polymer, therapeutic moiety or biomolecule.

- 5 [0330] Pharmaceutical compositions of the invention are suitable for use in a variety of drug delivery systems. Suitable formulations for use in the present invention are found in *Remington's Pharmaceutical Sciences*, Mace Publishing Company, Philadelphia, PA, 17th ed. (1985). For a brief review of methods for drug delivery, *see*, Langer, *Science* **249**:1527-1533 (1990).
- 10 [0331] The pharmaceutical compositions may be formulated for any appropriate manner of administration, including for example, topical, oral, nasal, intravenous, intracranial, intraperitoneal, subcutaneous or intramuscular administration. For parenteral administration, such as subcutaneous injection, the carrier preferably comprises water, saline, alcohol, a fat, a wax or a buffer. For oral administration, any of the above carriers or a solid carrier, such as  
15 mannitol, lactose, starch, magnesium stearate, sodium saccharine, talcum, cellulose, glucose, sucrose, and magnesium carbonate, may be employed. Biodegradable microspheres (*e.g.*, polylactate polyglycolate) may also be employed as carriers for the pharmaceutical compositions of this invention. Suitable biodegradable microspheres are disclosed, for example, in U.S. Patent Nos. 4,897,268 and 5,075,109.
- 20 [0332] Commonly, the pharmaceutical compositions are administered parenterally, *e.g.*, intravenously. Thus, the invention provides compositions for parenteral administration which comprise the compound dissolved or suspended in an acceptable carrier, preferably an aqueous carrier, *e.g.*, water, buffered water, saline, PBS and the like. The compositions may contain pharmaceutically acceptable auxiliary substances as required to approximate  
25 physiological conditions, such as pH adjusting and buffering agents, tonicity adjusting agents, wetting agents, detergents and the like.
- [0333] These compositions may be sterilized by conventional sterilization techniques, or may be sterile filtered. The resulting aqueous solutions may be packaged for use as is, or lyophilized, the lyophilized preparation being combined with a sterile aqueous carrier prior to  
30 administration. The pH of the preparations typically will be between 3 and 11, more preferably from 5 to 9 and most preferably from 7 and 8.

[0334]

In some embodiments the glycopeptides of the invention can be incorporated into liposomes formed from standard vesicle-forming lipids. A variety of methods are available for preparing liposomes, as described in, *e.g.*, Szoka *et al.*, *Ann. Rev. Biophys. Bioeng.* **9**: 467 (1980), U.S. Pat. Nos. 4,235,871, 4,501,728 and 4,837,028. The targeting of liposomes using a variety of targeting agents (*e.g.*, the sialyl galactosides of the invention) is well known in the art (*see, e.g.*, U.S. Patent Nos. 4,957,773 and 4,603,044).

[0335] Standard methods for coupling targeting agents to liposomes can be used. These methods generally involve incorporation into liposomes of lipid components, such as phosphatidylethanolamine, which can be activated for attachment of targeting agents, or derivatized lipophilic compounds, such as lipid-derivatized glycopeptides of the invention.

[0336] Targeting mechanisms generally require that the targeting agents be positioned on the surface of the liposome in such a manner that the target moieties are available for interaction with the target, for example, a cell surface receptor. The carbohydrates of the invention may be attached to a lipid molecule before the liposome is formed using methods known to those of skill in the art (*e.g.*, alkylation or acylation of a hydroxyl group present on the carbohydrate with a long chain alkyl halide or with a fatty acid, respectively).

Alternatively, the liposome may be fashioned in such a way that a connector portion is first incorporated into the membrane at the time of forming the membrane. The connector portion must have a lipophilic portion, which is firmly embedded and anchored in the membrane. It must also have a reactive portion, which is chemically available on the aqueous surface of the liposome. The reactive portion is selected so that it will be chemically suitable to form a stable chemical bond with the targeting agent or carbohydrate, which is added later. In some cases it is possible to attach the target agent to the connector molecule directly, but in most instances it is more suitable to use a third molecule to act as a chemical bridge, thus linking the connector molecule which is in the membrane with the target agent or carbohydrate which is extended, three dimensionally, off of the vesicle surface.

[0337] The compounds prepared by the methods of the invention may also find use as diagnostic reagents. For example, labeled compounds can be used to locate areas of inflammation or tumor metastasis in a patient suspected of having an inflammation. For this use, the compounds can be labeled with  $^{125}\text{I}$ ,  $^{14}\text{C}$ , or tritium.

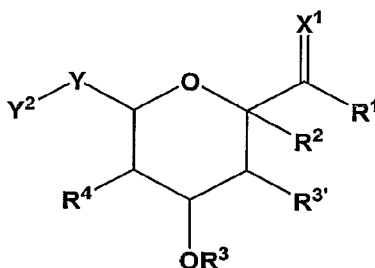
[0338] Moreover, the invention provides methods of preventing, curing or ameliorating a disease state by administering a conjugate of the invention to a subject at risk of developing

the disease or to a subject that has the disease. The conjugate is administered in a therapeutically effective amount. Because many of the conjugates, particularly those that include a polymeric modifying group, are anticipated to display enhanced in vivo residence times, a therapeutically effective dosage is readily determinable from a dosage of the non-conjugated therapeutic agent typically administered.

[0339] It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims. All publications, patents, and patent applications cited herein are hereby incorporated by reference in their entirety for all purposes.

**WHAT IS CLAIMED IS:**

1. A compound comprising a moiety represented by Formula I:



wherein

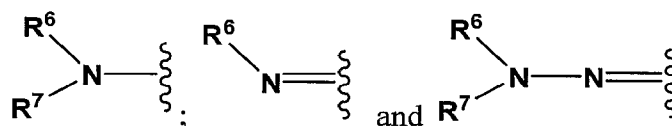
X<sup>1</sup> is a member selected from substituted or unsubstituted alkyl, O and NR<sup>8</sup>

wherein

R<sup>8</sup> is a member selected from H, OH, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl;

Y is a member selected from CH<sub>2</sub>, CH(OH)CH<sub>2</sub>, CH(OH)CH(OH)CH<sub>2</sub>, CH, CH(OH)CH or CH(OH)CH(OH)CH, CH(OH), CH(OH)CH(OH), and CH(OH)CH(OH)CH(OH);

Y<sup>2</sup> is a member selected from substituted or unsubstituted alkyl, R<sup>6</sup>, substituted or unsubstituted heteroalkyl



wherein

R<sup>6</sup> and R<sup>7</sup> are members independently selected from H, C(O)R<sup>6b</sup>, --L<sup>a</sup>-R<sup>6b</sup>, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl;

wherein

L<sup>a</sup> is a member selected from a bond and a linker group; and

R<sup>6b</sup> is a member selected from H and R<sup>6a</sup>

wherein

R<sup>6a</sup> is a modifying group

R<sup>1</sup> is a member selected from OR<sup>9</sup>, NR<sup>9</sup>R<sup>10</sup>, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl

wherein

R<sup>9</sup> and R<sup>10</sup> are members independently selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, and C(O)R<sup>11</sup>

wherein

R<sup>11</sup> is selected from substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl and substituted or unsubstituted heterocycloalkyl;

R<sup>2</sup> is a member selected from a nucleotide, an activating moiety, an amino acid residue of a peptide, a carbohydrate moiety attached to an amino acid residue of a peptide, and a carbohydrate moiety attached to an amino acid residue of a peptide through a linker comprising at least a second carbohydrate moiety;

R<sup>3</sup> is a member selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl;

R<sup>3'</sup> and R<sup>4</sup> are members independently selected from H, OH, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl and NHC(O)R<sup>12</sup>

wherein

R<sup>12</sup> is a member selected from substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, substituted or unsubstituted heterocycloalkyl and NR<sup>13</sup>R<sup>14</sup>

wherein

R<sup>13</sup> and R<sup>14</sup> are members independently selected from H, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl.

2. The compound according to claim 1, wherein Y<sup>2</sup> comprises at least one modifying group.

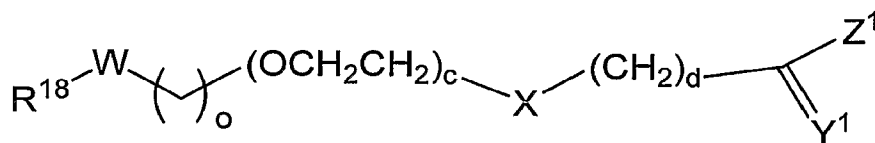
3. The compound according to claim 1, wherein R<sup>3'</sup> is H.

4. The compound according to claim 2, wherein at least one of R<sup>6</sup> and R<sup>7</sup> comprises a modifying group.

5. The compound according to claim 2, wherein said modifying group is a member selected from linear- and branched-poly(ethylene glycol).



6. The compound according to claim 5, wherein said PEG moiety is linear PEG and said linear PEG has a structure according to the following formula:



wherein

$R^{18}$  is a member selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted aryl, substituted or unsubstituted heteroaryl, substituted or unsubstituted heterocycloalkyl, substituted or unsubstituted heteroalkyl, *e.g.*, acetal, OHC-,  $H_2N-CH_2CH_2-$ ,  $HS-CH_2CH_2-$ , and  $-(CH_2)_qC(Y^1)Z^2$ ; -sugar-nucleotide, and protein;

$c$  is an integer selected from 1 to 2500;

$d$ ,  $o$ , and  $q$  are integers independently selected from 0 to 20;

$Z$  is a member selected from OH,  $NH_2$ , halogen,  $S-R^{19}$ , the alcohol portion of activated esters,  $-(CH_2)_{d1}C(Y^3)V$ ,  $-(CH_2)_{d1}U(CH_2)_gC(Y^3)_v$ , sugar-nucleotide, protein, and leaving groups, *e.g.*, imidazole, *p*-nitrophenyl, HOBT, tetrazole, and halide;

$X$ ,  $Y^1$ ,  $Y^3$ ,  $W$  and  $U$  are independently selected from O, S,  $N-R^{20}$ ;

$V$  is a member selected from OH,  $NH_2$ , halogen,  $S-R^{21}$ , the alcohol component of activated esters, the amine component of activated amides, sugar-nucleotides, and proteins;

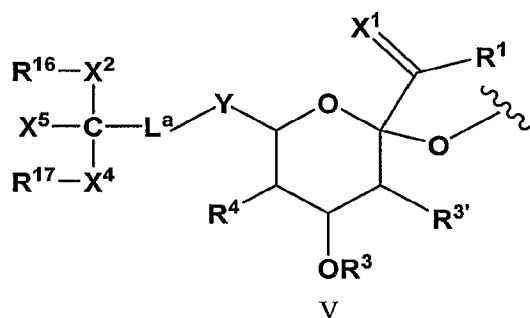
$d1$ ,  $g$  and  $v$  are integers independently selected from 0 to 20; and

$R^{19}$ ,  $R^{20}$  and  $R^{21}$  are independently selected from H, substituted or unsubstituted alkyl, substituted or unsubstituted heteroalkyl, substituted or unsubstituted aryl, substituted or unsubstituted heterocycloalkyl and substituted or unsubstituted heteroaryl.

7. The compound according to claim 6, wherein said linear PEG is attached to a member selected from a carbohydrate moiety attached to an amino acid residue

of said peptide, a carbohydrate moiety attached to an amino acid residue of said peptide through a linker comprising at least a second carbohydrate moiety.

8. The compound according to claim 5, wherein said moiety has a structure according to Formula V:



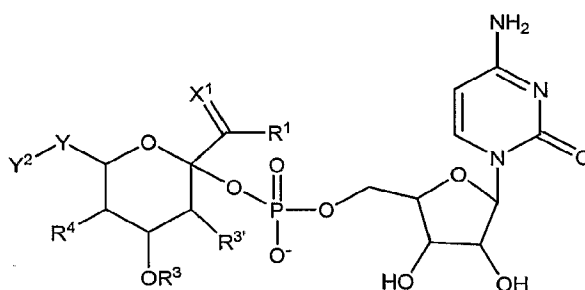
$L^a$  is a linker selected from a bond, substituted or unsubstituted alkyl and substituted or unsubstituted heteroalkyl

$R^{16}$  and  $R^{17}$  are independently selected polymeric arms;

$X^2$  and  $X^4$  are independently selected linkage fragments joining polymeric moieties  $R^{16}$  and  $R^{17}$  to C; and

$X^5$  is a non-reactive group.

9. The compound according to claim 1 having the formula:



10. The compound according to claim 1, wherein  $Y^2$  is  $N(R^6)-L^a-(m-PEG)_s$  wherein

$L^a$  is a linker moiety which is a member selected from an amino acid residue and a peptidyl residue; and  
s is an integer from 1 to 3.

1                   **11.**    A method of forming a covalent conjugate between a modified  
2    saccharyl fragment and a glycosylated or non-glycosylated peptide, said method comprising:  
3                   enzymatically transferring said modified saccharyl fragment from an activated  
4                   modified saccharyl fragment to an acceptor moiety on said peptide.

1                   **12.**    The method according to claim **11**, wherein said modified saccharyl  
2    fragment is covalently attached to a glycosyl residue covalently attached to said peptide.

1                   **13.**    The method according to claim **11**, wherein said modified saccharyl  
2    fragment is covalently attached to an amino acid residue of said peptide.

1                   **14.**    The method of claim **11**, wherein said enzyme is a glycosyltransferase  
2    which is a member selected from sialyl transferases, trans-sialidases, galactosyltransferases,  
3    glucosyltransferases, GalNAc transferase, GlcNAc transferase, fucosyl transferases, and  
4    mannosyltransferases.

1                   **15.**    The method of claim **14**, wherein said glycosyltransferase is  
2    recombinant.

1                   **16.**    The method according to claim **11**, wherein said method is performed  
2    in a cell-free environment.

1                   **17.**    A pharmaceutical composition comprising a pharmaceutically  
2    acceptable carrier and a conjugate comprising a modified saccharyl fragment covalently  
3    linked to a glycosylated or non-glycosylated peptide.

1                   **18.**    A composition for forming a conjugate between a peptide and a  
2    modified saccharyl fragment, said composition comprising: a mixture of an activated  
3    modified saccharyl fragment, an enzyme for which said activated modified saccharyl  
4    fragment is a substrate, and a peptide acceptor substrate, wherein said modified saccharyl  
5    fragment has covalently attached thereto a member selected from water-soluble polymers,  
6    therapeutic moieties and biomolecules.

12AP1/E5 -- Viventia Biotech	AI-201 -- AutoImmune
1964 -- Aventis	AI-301 -- AutoImmune
20K growth hormone -- AMUR	AIDS vaccine -- ANRS, CIBG, Hesed
28P6/E6 -- Viventia Biotech	Biomed, Hollis-Eden, Rome, United
3-Hydroxyphthaloyl-beta-lactoglobulin --	Biomedical, American Home Products,
4-IBB ligand gene therapy --	Maxygen
64-Cu MAb conjugate TETA-1A3 --	airway receptor ligand -- IC Innovations
Mallinckrodt Institute of Radiology	AJvW 2 -- Ajinomoto
64-Cu MAb conjugate TETA-cT84.66	AK 30 NGF -- Alkermes
64-Cu Trastuzumab TETA conjugate --	Albuferon -- Human Genome Sciences
Genentech	albumin -- Biogen, DSM Anti-Infectives,
A 200 -- Amgen	Genzyme Transgenics, PPL Therapeutics,
A10255 -- Eli Lilly	TranXenoGen, Welfide Corp.
A1PDX -- Hedral Therapeutics	aldesleukin -- Chiron
A6 -- Angstrom	alefacept -- Biogen
aaAT-III -- Genzyme	Alemtuzumab --
Abciximab -- Centocor	Allergy therapy -- ALK-Abello/Maxygen,
ABI.001 -- Atlantic BioPharmaceuticals	ALK-Abello/RP Scherer
ABT-828 -- Abbott	allergy vaccines -- Allergy Therapeutics
Accutin	Alnidofibatide -- Aventis Pasteur
Actinohivin	Alnorine -- SRC VB VECTOR
activin -- Biotech Australia, Human	ALP 242 -- Gruenenthal
Therapeutics	Alpha antitrypsin -- Arriva/Hyland
activin -- Curis	Immuno/ProMetic/Protease Sciences
AD 439 -- Tanox	Alpha-1 antitrypsin -- Cutter, Bayer, PPL
AD 519 -- Tanox	Therapeutics, Profile, ZymoGenetics,
Adalimumab -- Cambridge Antibody Tech.	Arriva
Adenocarcinoma vaccine -- Biomira -- NIS	Alpha-1 protease inhibitor -- Genzyme
Adenosine A2B receptor antagonists --	Transgenics, Welfide Corp.
Adenosine Therapeutics	Alpha-galactose fusion protein --
ADP-001 -- Axis Genetics	Immunomedics
AF 13948 -- Affymax	Alpha-galactosidase A -- Research
Afelimomab -- Knoll	Corporation Technologies
AFP-SCAN -- Immunomedics	Alpha-glucosidase -- Genzyme, Novazyme
AG 2195 -- Corixa	Alpha-lactalbumin
agalsidase alfa -- Transkaryotic Therapies	Alpha-L-iduronidase -- Transkaryotic
agalsidase beta -- Genzyme	Therapies, BioMarin
AGENT-- Antisoma	alteplase -- Genentech
AI 300 -- AutoImmune	alvircept sudotox -- NIH
AI-101 -- Teva	ALX1-11 --sNPS Pharmaceuticals
AI-102 -- Teva	Alzheimer's disease gene therapy --

**FIG. 1A**

AM-133 -- AMRAD	Anti-B4 MAb-DC1 conjugate -- ImmunoGen
Amb a 1 immunostim conj. -- Dynavax	Anti-B7 antibody PRIMATIZED -- IDEC
AMD 3100 -- AnorMED -- NIS	Anti-B7-1 MAb 16-10A1
AMD 3465 -- AnorMED -- NIS	Anti-B7-1 MAb 1G10
AMD 3465 -- AnorMED -- NIS	Anti-B7-2 MAb GL-1
AMD Fab -- Genentech	Anti-B7-2-gelonin immunotoxin --
Amediplase -- Menarini, Novartis	Antibacterials/antifungals --
AM-F9	Diversa/IntraBiotics
Amoebiasis vaccine	Anti-beta-amyloid monoclonal antibodies --
Amphiregulin -- Octagene	Cambridge Antibody Tech., Wyeth-Ayerst
anakinra -- Amgen	Anti-BLyS antibodies -- Cambridge
analgesic -- Nobex	Antibody Tech. /Human Genome Sciences
ancestim -- Amgen	Antibody-drug conjugates -- Seattle
AnergiX.RA -- Corixa, Organon	Genetics/Eos
Angiocidin -- InKine	Anti-C5 MAb BB5-1 -- Alexion
angiogenesis inhibitors -- ILEX	Anti-C5 MAb N19-8 -- Alexion
AngioMab -- Antisoma	Anti-C8 MAb
Angiopoietins -- Regeneron/Procter &	anticancer cytokines -- BioPulse
Gamble	anticancer matrix -- Telios Integra
angiostatin -- EntreMed	Anticancer monoclonal antibodies -- ARIUS,
Angiostatin/endostatin gene therapy --	Immunex
Genetix Pharmaceuticals	anticancer peptides -- Maxygen, Micrologix
angiotensin-II, topical -- Maret	Anticancer prodrug Tech. -- Alexion
Anthrax -- EluSys Therapeutics/US Army	Antibody Technologies
Medical Research Institute	anticancer Troy-Bodies -- Affite -- Affitech
Anthrax vaccine	anticancer vaccine -- NIH
Anti platelet-derived growth factor D human	anticancers -- Epimmune
monoclonal antibodies -- CuraGen	Anti-CCR5/CXCR4 sheep MAb -- KS
Anti-17-1A MAb 3622W94 --	Biomedix Holdings
GlaxoSmithKline	Anti-CD11a MAb KBA --
Anti-2C4 MAb -- Genentech	Anti-CD11a MAb M17
anti-4-1BB monoclonal antibodies -- Bristol-	Anti-CD11a MAb TA-3 --
Myers Squibb	Anti-CD11a MAb WT.1 --
Anti-Adhesion Platform Tech. -- Cytovax	Anti-CD11b MAb -- Pharmacia
Anti-adipocyte MAb -- Cambridge Antibody	Anti-CD11b MAb LM2
Tech./ObeSys	Anti-CD154 MAb -- Biogen
antiallergics -- Maxygen	Anti-CD16-anti-CD30 MAb -- Biotest
antiallergy vaccine -- Acambis	Anti-CD18 MAb -- Pharmacia
Anti-alpha-4-integrin MAb	Anti-CD19 MAb B43 --
Anti-angiogenesis monoclonal antibodies --	Anti-CD19 MAb -liposomal sodium butyrate
KS Biomedix/Schering AG	conjugate --

**FIG. 1B**

Anti-CD19 MAb-saporin conjugate –	Anti-CD4 MAb KT6
Anti-CD19-dsFv-PE38-immunotoxin –	Anti-CD4 MAb OX38
Anti-CD2 MAb 12-15 –	Anti-CD4 MAb PAP conjugate -- Bristol-
Anti-CD2 MAb B-E2 -- Diaclone	Myers Squibb
Anti-CD2 MAb OX34 –	Anti-CD4 MAb RIB 5-2
Anti-CD2 MAb OX54 –	Anti-CD4 MAb W3/25
Anti-CD2 MAb OX55 –	Anti-CD4 MAb YTA 3.1.2
Anti-CD2 MAb RM2-1	Anti-CD4 MAb YTS 177-9
Anti-CD2 MAb RM2-2	Anti-CD40 ligand MAb 5c8 -- Biogen
Anti-CD2 MAb RM2-4	Anti-CD40 MAb
Anti-CD20 MAb BCA B20	Anti-CD40 MAb 5D12 – Tanox
Anti-CD20-anti-Fc alpha RI bispecific MAb –	Anti-CD44 MAb A3D8
Medarex, Tenovus	Anti-CD44 MAb GKWA3
Anti-CD22 MAb-saporin-6 complex –	Anti-CD44 MAb IM7
Anti-CD3 immunotoxin –	Anti-CD44 MAb KM81
Anti-CD3 MAb 145-2C11 -- Pharming	Anti-CD44 variant monoclonal antibodies --
Anti-CD3 MAb CD4IgG conjugate --	Corixa/Hebrew University
Genentech	Anti-CD45 MAb BC8-I-131
Anti-CD3 MAb humanised – Protein Design,	Anti-CD45RB MAb
RW Johnson	Anti-CD48 MAb HuLy-m3
Anti-CD3 MAb WT32	Anti-CD48 MAb WM-63
Anti-CD3 MAb-ricin-chain-A conjugate –	Anti-CD5 MAb -- Becton Dickinson
Anti-CD3 MAb-xanthine-oxidase conjugate	Anti-CD5 MAb OX19
–	Anti-CD6 MAb
Anti-CD30 MAb BerH2 -- Medac	Anti-CD7 MAb-PAP conjugate
Anti-CD30 MAb-saporin conjugate	Anti-CD7 MAb-ricin-chain-A conjugate
Anti-CD30-scFv-ETA'-immunotoxin	Anti-CD8 MAb – Amerimmune, Cytodyn,
Anti-CD38 MAb AT13/5	Becton Dickinson
Anti-CD38 MAb-saporin conjugate	Anti-CD8 MAb 2-43
Anti-CD3-anti-CD19 bispecific MAb	Anti-CD8 MAb OX8
Anti-CD3-anti-EGFR MAb	Anti-CD80 MAb P16C10 -- IDEC
Anti-CD3-anti-interleukin-2-receptor MAb	Anti-CD80 MAb P7C10 -- ID Vaccine
Anti-CD3-anti-MOV18 MAb -- Centocor	Anti-CD8-idarubicin conjugate
Anti-CD3-anti-SCLC bispecific MAb	Anti-CEA MAb CE-25
Anti-CD4 idiotype vaccine	Anti-CEA MAb MN 14 – Immunomedics
Anti-CD4 MAb – Centocor, IDEC	Anti-CEA MAb MN14-PE40 conjugate –
Pharmaceuticals, Xenova Group	Immunomedics
Anti-CD4 MAb 16H5	Anti-CEA MAb T84.66-interleukin-2
Anti-CD4 MAb 4162W94 -- GlaxoSmithKline	conjugate
Anti-CD4 MAb B-F5 -- Diaclone	Anti-CEA sheep MAb -- KS Biomedix
Anti-CD4 MAb GK1-5	Holdings

FIG. 1C

Anti-cell surface monoclonal antibodies -- Cambridge Antibody Tech. /Pharmacia	Anti-HIV antibody -- Epicyte
Anti-c-erbB2-anti-CD3 bifunctional MAb -- Otsuka	anti-HIV catalytic antibody -- Hesed Biomed
Anti-CMV MAb -- Scotgen	anti-HIV fusion protein -- Idun
Anti-CTLA-4 MAb	anti-HIV proteins -- Cangene
Anti-EGFR catalytic antibody -- Hesed Biomed	Anti-HM1-24 MAb -- Chugai
anti-EGFR immunotoxin -- IVAX	Anti-hR3 MAb
Anti-EGFR MAb -- Abgenix	Anti-Human-Carcinoma-Antigen MAb -- Epicyte
Anti-EGFR MAb 528	Anti-ICAM-1 MAb -- Boehringer Ingelheim
Anti-EGFR MAb KSB 107 -- KS Biomedix	Anti-ICAM-1 MAb 1A-29 -- Pharmacia
Anti-EGFR MAb-DM1 conjugate -- ImmunoGen	Anti-ICAM-1 MAb HA58
Anti-EGFR MAb-LA1 --	Anti-ICAM-1 MAb YN1/1.7.4
Anti-EGFR sheep MAb -- KS Biomedix	Anti-ICAM-3 MAb ICM3 -- ICOS
Anti-FAP MAb F19-I-131	Anti-idiotypic breast cancer vaccine 11D10
Anti-Fas IgM MAb CH11	Anti-idiotypic breast cancer vaccine ACA14C5 --
Anti-Fas MAb Jo2	Anti-idiotypic cancer vaccine -- ImClone Systems/Merck KGaA ImClone, Viventia Biotech
Anti-Fas MAb RK-8	Anti-idiotypic cancer vaccine 1A7 -- Titan
Anti-Flt-1 monoclonal antibodies -- ImClone	Anti-idiotypic cancer vaccine 3H1 -- Titan
Anti-fungal peptides -- State University of New York	Anti-idiotypic cancer vaccine TriAb -- Titan
antifungal tripeptides -- BTG	Anti-idiotypic Chlamydia trachomatis vaccine
Anti-ganglioside GD2 antibody-interleukin-2 fusion protein -- Lexigen	Anti-idiotypic colorectal cancer vaccine -- Novartis
Anti-GM2 MAb -- Kyowa	Anti-idiotypic colorectal cancer vaccine -- Onyvax
Anti-GM-CSF receptor monoclonal antibodies -- AMRAD	Anti-idiotypic melanoma vaccine -- IDEC Pharmaceuticals
Anti-gp130 MAb -- Tosoh	Anti-idiotypic ovarian cancer vaccine ACA 125
Anti-HCA monoclonal antibodies -- AltaRex/Epigen	Anti-idiotypic ovarian cancer vaccine AR54 - - AltaRex
Anti-hCG antibodies -- Abgenix/AVI BioPharma	Anti-idiotypic ovarian cancer vaccine CA-125 -- AltaRex, Biomira
Anti-heparanase human monoclonal antibodies -- Oxford Glycosciences/Medarex	Anti-IgE catalytic antibody -- Hesed Biomed
Anti-hepatitis C virus human monoclonal antibodies -- XTL Biopharmaceuticals	Anti-IgE MAb E26 -- Genentech
Anti-HER-2 antibody gene therapy	Anti-IGF-1 MAb
Anti-herpes antibody -- Epicyte	anti-inflammatory -- GeneMax
	anti-inflammatory peptide -- BTG

FIG. 1D

anti-integrin peptides -- Burnha	Anti-mu MAb -- Novartis
Anti-interferon-alpha-receptor MAb 64G12 -- Pharma Pacific Management	Anti-MUC-1 MAb
Anti-interferon-gamma MAb -- Protein Design Labs	Anti-Nogo-A MAb IN1
Anti-interferon-gamma polyclonal antibody - - Advanced Biotherapy	Anti-nuclear autoantibodies -- Procyon
Anti-interleukin-10 MAb --	Anti-ovarian cancer monoclonal antibodies - - Dompe
Anti-interleukin-12 MAb --	Anti-p185 monoclonal antibodies
Anti-interleukin-1-beta polyclonal antibody -- R&D Systems	Anti-p43 MAb
Anti-interleukin-2 receptor MAb 2A3	Antiparasitic vaccines
Anti-interleukin-2 receptor MAb 33B3-1 -- Immunotech	Anti-PDGF/bFGF sheep MAb -- KS Biomedix
Anti-interleukin-2 receptor MAb ART-18	Anti-properdin monoclonal antibodies -- Abgenix/Gliatech
Anti-interleukin-2 receptor MAb LO-Tact-1	Anti-PSMA MAb J591 -- BZL Biologics
Anti-interleukin-2 receptor MAb Mikbeta1	Anti-Rev MAb gene therapy --
Anti-interleukin-2 receptor MAb NDS61	Anti-RSV antibodies -- Epicyte, Intracell
Anti-interleukin-4 MAb 11B11	Anti-RSV monoclonal antibodies -- Medarex/MedImmune, Applied Molecular Evolution/MedImmune
Anti-interleukin-5 MAb -- Wallace Laboratories	Anti-RSV MAb, inhalation -- Alkermes/MedImmune
Anti-interleukin-6 MAb -- Centocor, Diaclone, Pharmadigm	Anti-RT gene therapy
Anti-interleukin-8 MAb -- Xenotech	Antisense K-ras RNA gene therapy
Anti-JL1 MAb	Anti-SF-25 MAb
Anti-Klebsiella sheep MAb -- KS Biomedix Holdings	Anti-sperm antibody -- Epicyte
Anti-Laminin receptor MAb-liposomal doxorubicin conjugate	Anti-Tac(Fv)-PE38 conjugate
Anti-LCG MAb -- Cytoclonal	Anti-TAPA/CD81 MAb AMP1
Anti-lipopolysaccharide MAb -- VitaResc	Anti-tat gene therapy
Anti-L-selectin monoclonal antibodies -- Protein Design Labs, Abgenix, Stanford University	Anti-TCR-alphabeta MAb H57-597
Anti-MBL monoclonal antibodies -- Alexion/Brigham and Women's Hospital	Anti-TCR-alphabeta MAb R73
Anti-MHC monoclonal antibodies	Anti-tenascin MAb BC-4-I-131
Anti-MIF antibody humanised -- IDEC, Cytokine PharmaSciences	Anti-TGF-beta human monoclonal antibodies -- Cambridge Antibody Tech., Genzyme
Anti-MRSA/VRSA sheep MAb -- KS Biomedix Holdings	Anti-TGF-beta MAb 2G7 -- Genentech
	Antithrombin III -- Genzyme Transgenics, Aventis, Bayer, Behringwerke, CSL, Myriad
	Anti-Thy1 MAb
	Anti-Thy1.1 MAb

FIG. 1E



Anti-tissue factor/factor VIIA sheep MAb -- KS Biomedix	ARGENT gene delivery systems -- ARIAD
Anti-TNF monoclonal antibodies -- Centocor, Chiron, Peptech, Pharacia, Serono	Arresten
Anti-TNF sheep MAb -- KS Biomedix Holdings	ART-123 -- Asahi Kasei
Anti-TNFalpha MAb -- Genzyme	arylsulfatase B -- BioMarin
Anti-TNFalpha MAb B-C7 -- Diaclone	Arylsulfatase B, Recombinant human -- BioMarin
Anti-tooth decay MAb -- Planet BioTech.	AS 1051 -- Ajinomoto
antitumour RNases -- NIH	ASI-BCL -- Intracell
Anti-VCAM MAb 2A2 -- Alexion	ATL-101 -- Alizyme
Anti-VCAM MAb 3F4 -- Alexion	atrial natriuretic peptide -- Pharis
Anti-VCAM-1 MAb	Aurintricarboxylic acid-high molecular weight
Anti-VEC MAb -- ImClone	autoimmune disorders -- GPC
Anti-VEGF MAb -- Genentech	Biotech/MorphoSys
Anti-VEGF MAb 2C3	Autoimmune disorders and transplant rejection -- Bristol-Myers Squibb/Genzyme
Anti-VEGF sheep MAb -- KS Biomedix Holdings	Tra
Anti-VLA-4 MAb HP1/2 -- Biogen	Autoimmune disorders/cancer -- Abgenix/Chiron, /CuraGen
Anti-VLA-4 MAb PS/2	Autotaxin
Anti-VLA-4 MAb R1-2	Avicidin -- NeoRx
Anti-VLA-4 MAb TA-2	axogenesis factor-1 -- Boston Life Sciences
Anti-VRE sheep MAb -- KS Biomedix Holdings	Axokine -- Regeneron
ANUP -- TranXenoGen	B cell lymphoma vaccine -- Biomira
ANUP-1 -- Pharis	B7-1 gene therapy --
AOP-RANTES -- Senetek	BABS proteins -- Chiron
Apan-CH -- Praecis Pharmaceuticals	BAM-002 -- Novelos Therapeutics
APC-8024 -- Demegen	Bay-16-9996 -- Bayer
ApoA-1 -- Milano, Pharmacia	Bay-39-9437 -- Bayer
Apogen -- Alexion	Bay-50-4798 -- Bayer
apolipoprotein A1 -- Avanir	BB-10153 -- British Biotech
Apolipoprotein E -- Bio-Tech. General	BBT-001 -- Bolder BioTech.
Applaggin -- Biogen	BBT-002 -- Bolder BioTech.
aprotinin -- ProdiGene	BBT-003 -- Bolder BioTech.
APT-070C -- AdProTech	BBT-004 -- Bolder BioTech.
AR 177 -- Aronex Pharmaceuticals	BBT-005 -- Bolder BioTech.
AR 209 -- Aronex Pharmaceuticals, Antigenics	BBT-006 -- Bolder BioTech.
AR545C	BBT-007 -- Bolder BioTech.
	BCH-2763 -- Shire
	BCSF -- Millenium Biologix
	BDNF -- Regeneron -- Amgen

FIG. 1F

Becaplermin -- Johnson & Johnson, Chiron	BST-3002 -- BioStratum
Bectumomab -- Immunomedics	BTI 322 --
Beta-adrenergic receptor gene therapy -- University of Arkansas	butyrylcholinesterase -- Shire
BI 51013 -- Behringwerke AG	C 6822 -- COR Therapeutics
BIBH 1 -- Boehringer Ingelheim	C1 esterase inhibitor -- Pharming
BIM-23190 -- Beaufour-Ipsen	C3d adjuvant -- AdProTech
birch pollen immunotherapy -- Pharmacia	CAB-2.1 -- Millennium
bispecific fusion proteins -- NIH	calcitonin -- Inhale Therapeutics Systems, Aventis, Genetronics, TranXenoGen, Unigene, Rhone Poulenc Rohrer
Bispecific MAb 2B1 -- Chiron	calcitonin -- oral -- Nobex, Emisphere, Pharmaceutical Discovery
Bitistatin	Calcitonin gene-related peptide -- Asahi Kasei -- Unigene
BIWA 4 -- Boehringer Ingelheim	calcitonin, human -- Suntory
blood substitute -- Northfield, Baxter Intl.	calcitonin, nasal -- Novartis, Unigene
BLP-25 -- Biomira	calcitonin, Panoderm -- Elan
BLS-0597 -- Boston Life Sciences	calcitonin, Peptitrol -- Shire
BLyS -- Human Genome Sciences	calcitonin, salmon -- Therapicon
BLyS radiolabelled -- Human Genome Sciences	calin -- Biopharm
BM 06021 -- Boehringer Mannheim	Calphobindin I
BM-202 -- BioMarin	calphobindin I -- Kowa
BM-301 -- BioMarin	calreticulin -- NYU
BM-301 -- BioMarin	Campath-1G
BM-302 -- BioMarin	Campath-1M
BMP 2 -- Genetics Institute/Medtronic- Sofamor Danek, Genetics Institute/ Collagenesis, Genetics Institute/Yamanouch	cancer therapy -- Cangene
BMP 2 gene therapy	cancer vaccine -- Aixlie, Aventis Pasteur, Center of Molecular Immunology, YM BioSciences, Cytos, Genzyme, Transgenics, GlobelImmune, Igeneon, ImClone, Virogenetics, InterCell, Iomai, Jenner Biotherapies, Memorial Sloan- Kettering Cancer Center, Sydney Kimmel Cancer Center, Novavax, Protein Sciences, Argonex, SIGA
BMP 52 -- Aventis Pasteur, Biopharm	Cancer vaccine ALVAC-CEA B7.1 -- Aventis Pasteur/Therion Biologics
BMP-2 -- Genetics Institute	Cancer vaccine CEA-TRICOM -- Aventis Pasteur/Therion Biologics
BMS 182248 -- Bristol-Myers Squibb	Cancer vaccine gene therapy -- Cantab Pharmaceuticals
BMS 202448 -- Bristol-Myers Squibb	
bone growth factors -- IsoTis	
BPC-15 -- Pfizer	
brain natriuretic peptide --	
Breast cancer -- Oxford GlycoSciences/Medarex	
Breast cancer vaccine -- Therion Biologics, Oregon	
BSSL -- PPL Therapeutics	
BST-2001 -- BioStratum	

**FIG. 1G**

Cancer vaccine HER-2/neu -- Corixa	CETP vaccine -- Avant
Cancer vaccine THERATOPE -- Biomira	Cetrorelix
cancer vaccine, PolyMASC -- Valentis	Cetuximab
Candida vaccine -- Corixa, Inhibitex	CGH 400 -- Novartis
Canstatin -- ILEX	CGP 42934 -- Novartis
CAP-18 -- Panorama	CGP 51901 -- Tanox
Cardiovascular gene therapy -- Collateral Therapeutics	CGRP -- Unigene
carperitide -- Suntory	CGS 27913 -- Novartis
Casocidin-1 -- Pharis	CGS 32359 -- Novartis
CAT 152 -- Cambridge Antibody Tech.	Chagas disease vaccine -- Corixa
CAT 192 -- Cambridge Antibody Tech.	chemokines -- Immune Response
CAT 213 -- Cambridge Antibody Tech.	CHH 380 -- Novartis
Catalase -- Enzon	chitinase -- Genzyme, ICOS
Cat-PAD -- Circassia	Chlamydia pneumoniae vaccine -- Antex Biologics
CB 0006 -- Celltech	Chlamydia trachomatis vaccine -- Antex Biologics
CCK(27-32) -- Akzo Nobel	Chlamydia vaccine -- GlaxoSmithKline
CCR2-64I -- NIH	Cholera vaccine CVD 103-HgR -- Swiss Serum and Vaccine Institute Berne
CD, Procept -- Paligent	Cholera vaccine CVD 112 -- Swiss Serum and Vaccine Institute Berne
CD154 gene therapy	Cholera vaccine inactivated oral -- SBL Vaccin
CD39 -- Immunex	Chrysalin -- Chrysalis BioTech.
CD39-L2 -- Hyseq	CI-782 -- Hitachi Kase
CD39-L4 -- Hyseq	Ciliary neurotrophic factor -- Fidia, Roche
CD4 fusion toxin -- Senetek	CIM project -- Active Biotech
CD4 IgG -- Genentech	CL 329753 -- Wyeth-Ayerst
CD4 receptor antagonists -- Pharmacopeia/Progenics	CL22, Cobra -- ML Laboratories
CD4 soluble -- Progenics	Clenoliximab -- IDEC
CD4, soluble -- Genzyme Transgenics	Clostridium difficile antibodies -- Epicyte
CD40 ligand -- Immunex	clotting factors -- Octagene
CD4-ricin chain A -- Genentech	CMB 401 -- Celltech
CD59 gene therapy -- Alexion	CNTF -- Sigma-Tau
CD8 TIL cell therapy -- Aventis Pasteur	Cocaine abuse vaccine -- Cantab, ImmuLogic, Scripps
CD8, soluble -- Avidex	coccidiomycosis vaccine -- Arizo
CD95 ligand -- Roche	collagen -- Type I -- Pharming
CDP 571 -- Celltech	Collagen formation inhibitors -- FibroGen
CDP 850 -- Celltech	
CDP 870 -- Celltech	
CDS-1 -- Ernest Orlando	
Cedelizumab -- Ortho-McNeil	
Cetermin -- Insmed	

FIG. 1H

Collagen/hydroxyapatite/bone growth factor	CY 1747 -- Epimmune
-- Aventis Pasteur, Biopharm, Orquest	CY 1748 -- Epimmune
collagenase -- BioSpecifics	Cyanovirin-N
Colorectal cancer vaccine -- Wistar Institute	Cystic fibrosis therapy -- CBR/IVAX
Component B, Recombinant -- Serono	CYT 351
Connective tissue growth factor inhibitors --	cytokine Traps -- Regeneron
FibroGen/Taisho	cytokines -- Enzon, Cytoclonal
Contortrostatin	Cytomegalovirus glycoprotein vaccine --
contraceptive vaccine -- Zonagen	Chiron, Aquila Biopharmaceuticals,
Contraceptive vaccine hCG	Aventis Pasteur, Virogenetics
Contraceptive vaccine male reversible --	Cytomegalovirus vaccine live -- Aventis
IMMUCON	Pasteur
Contraceptive vaccine zona pellucida --	Cytosine deaminase gene therapy --
Zonagen	GlaxoSmithKline
Copper-64 labelled MAb TETA-1A3 -- NCI	DA-3003 -- Dong-A
Coralayne	DAB389interleukin-6 -- Senetek
Corsevin M	DAB389interleukin-7
C-peptide analogues -- Schwarz	DAMP <sup>^</sup> -- Incyte Genomics
CPI-1500 -- Consensus	Daniplestim -- Pharmacia
CRF -- Neurobiological Tech.	darbepoetin alfa -- Amgen
cRGDfV pentapeptide --	DBI-3019 -- Diabetogen
CRL 1095 -- CytRx	DCC -- Genzyme
CRL 1336 -- CytRx	DDF -- Hyseq
CRL 1605 -- CytRx	decorin -- Integra, Telios
CS-560 -- Sankyo	defensins -- Large Scale Biology
CSF -- ZymoGenetics	DEGR-VIIa
CSF-G -- Hangzhou, Dong-A, Hanmi	Deimmunised antibody 3B6/22 AGEN
CSF-GM -- Cangene, Hunan, LG Chem	Deimmunised anti-cancer antibodies --
CSF-M -- Zarix	Biovation/Viragen
CT 1579 -- Merck Frosst	Dendroamide A
CT 1786 -- Merck Frosst	Dengue vaccine -- Bavarian Nordic, Merck
CT-112 <sup>^</sup> -- BTG	denileukin diftitox -- Ligand
CTB-134L -- Xenova	DES-1101 -- Desmos
CTC-111 -- Kaketsuken	desirudin -- Novartis
CTGF -- FibroGen	desmopressin -- Unigene
CTLA4-Ig -- Bristol-Myers Squibb	Desmoteplase -- Merck, Schering AG
CTLA4-Ig gene therapy --	Destabilase
CTP-37 -- AVI BioPharma	Diabetes gene therapy -- DeveloGen, Pfizer
C-type natriuretic peptide -- Suntory	Diabetes therapy -- Crucell
CVS 995 -- Corvas Intl.	Diabetes type 1 vaccine -- Diamyd
CX 397 -- Nikko Kyodo	Therapeutics

FIG. 11

DiaCIM -- YM BioSciences	EGF-P64k vaccine -- Center of Molecular Immunology
dialytic oligopeptides -- Research Corp	EL 246 -- LigoCyte
Diamyd -- Diamyd Therapeutics	elastase inhibitor -- Synergen
DiaPep227-- Pepgen	elcatonin -- Therapicon
DiavaX -- Corixa	EMD 72000 -- Merck KGaA
Diphtheria tetanus pertussis-hepatitis B vaccine -- GlaxoSmithKline	Emdogain -- BIORA
DIR therapy -- Solis Therapeutics --	emfilermin -- AMRAD
DNase -- Genentech	Emoctakin -- Novartis
Dornase alfa -- Genentech	enamel matrix protein -- BIORA
Dornase alfa, inhalation -- Genentech	Endo III -- NYU
Doxorubicin-anti-CEA MAb conjugate -- Immunomedics	endostatin -- EntreMed, Pharis
DP-107 -- Trimeris	Enhancins -- Micrologix
drotrecogin alfa -- Eli Lilly	Enlimomab -- Isis Pharm.
DTctGMCSF	Enoxaparin sodium -- Pharmuka
DTP-polio vaccine -- Aventis Pasteur	enzyme linked antibody nutrient depletion therapy -- KS Biomedix Holdings
DU 257-KM231 antibody conjugate -- Kyowa	Eosinophil-derived neutralizing agent --
dural graft matrix -- Integra	EP-51216 -- Asta Medica
Dutepase -- Baxter Intl.	EP-51389 -- Asta Medica
DWP-401 -- Daewoong	EPH family ligands -- Regeneron
DWP-404 -- Daewoong	Epidermal growth factor -- Hitachi Kasei, Johnson & Johnson
DWP-408 -- Daewoong	Epidermal growth factor fusion toxin -- Senetek
E coli O157 vaccine -- NIH	Epidermal growth factor-genistein --
E21-R -- BresaGen	EPI-HNE-4 -- Dyax
Eastern equine encephalitis virus vaccine --	EPI-KAL2 -- Dyax
Echicetin --	Epoetin-alfa -- Amgen, Dragon Pharmaceuticals, Nanjing Huaxin
Echinhibin 1 --	Epratuzumab -- Immunomedics
Echistatin -- Merck	Epstein-Barr virus vaccine -- Aviron/SmithKline Beecham, BioResearch
Echitamine --	Eptacog alfa -- Novo Nordisk
EC-SOD -- PPL Therapeutics	Eptifibatide -- COR Therapeutics
EDF -- Ajinomoto	erb-38 --
EDN derivative -- NIH	Erlizumab -- Genentech
EDNA -- NIH	
Edobacomab -- XOMA	
Edrecolomab -- Centocor	
EF 5077	
Efalizumab -- Genentech	
EGF fusion toxin -- Seragen, Ligand	

erythropoietin -- Alkermes, ProLease, Dong-A, Elanex, Genetics Institute, LG Chem, Protein Sciences, Serono, Snow Brand, SRC VB VECTOR, Transkaryotic Therapies	Fas TR -- Human Genome Sciences
Erythropoietin Beta -- Hoffman La Roche	Felvizumab -- Scotgen
Erythropoietin/Epoetin alfa -- Chugai	FFR-VIIa -- Novo Nordisk
Escherichia coli vaccine -- North American Vaccine, SBL Vaccin, Swiss Serum and Vaccine Institute Berne	FG-001 -- F-Gene
etanercept -- Immunex	FG-002 -- F-Gene
examorelin -- Mediolanum	FG-004 -- F-Gene
exonuclease VII	FG-005 -- F-Gene
F 105 -- Centocor	FGF + fibrin -- Repair
F-992 -- Fornix	Fibrimage -- Bio-Tech. General
Factor IX -- Alpha Therapeutics, Welfide Corp., CSL, enetics Institute/AHP, Pharmacia, PPL Therapeutics	fibrin-binding peptides -- ISIS Innovation
Factor IX gene therapy -- Cell Genesys	fibrinogen -- PPL Therapeutics, Pharming
Factor VII -- Novo Nordisk, Bayer, Baxter Intl.	fibroblast growth factor -- Chiron, NYU, Ramot, ZymoGenetics
Factor VIIa -- PPL Therapeutics, ZymoGenetics	fibrolase conjugate -- Schering AG
Factor VIII -- Bayer Genentech, Beaufour-Ipsen, CLB, Inex, Octagen, Pharmacia, Pharming	Filgrastim -- Amgen
Factor VIII -- PEGylated -- Bayer	filgrastim -- PDA modified -- Xencor
Factor VIII fragments -- Pharmacia	FLT-3 ligand -- Immunex
Factor VIII gene therapy -- Targeted Genetics	FN18 CRM9 --
Factor VIII sucrose formulation -- Bayer, Genentech	folistatin -- Biotech Australia, Human Therapeutics
Factor VIII-2 -- Bayer	folitropin alfa -- Alkermes, ProLease, PowderJect, Serono, Akzo Nobel
Factor VIII-3 -- Bayer	Follitropin Beta -- Bayer, Organon
Factor Xa inhibitors -- Merck, Novo Nordisk, Mochida	FP 59
Factor XIII -- ZymoGenetics	FSH -- Ferring
Factors VIII and IX gene therapy -- Genetics Institute/Targeted Genetics	FSH + LH -- Ferring
Famoxin -- Genset	F-spondin -- CeNeS
Fas (delta) TM protein -- LXR BioTech.	fusion protein delivery system -- UAB Research Foundation
	fusion toxins -- Boston Life Sciences
	G 5598 -- Genentech
	GA-II -- Transkaryotic Therapies
	Gamma-interferon analogues -- SRC VB VECTOR
	Ganirelix -- Roche
	gastric lipase -- Meristem
	Gavilimomab --
	G-CSF -- Amgen, SRC VB VECTOR
	GDF-1 -- CeNeS
	GDF-5 -- Biopharm
	GDNF -- Amgen

FIG. 1K

gelsolin -- Biogen	H5N1 influenza A virus vaccine -- Protein Sciences
Gemtuzumab ozogamicin -- Celltech	haemoglobin -- Biopure
Gene-activated epoetin-alfa -- Aventis Pharma -- Transkaryotic Therapies	haemoglobin 3011, Recombinant -- Baxter Healthcare
Glanzmann thrombasthenia gene therapy --	haemoglobin crosfumaril -- Baxter Intl.
Glatiramer acetate -- Yeda	haemoglobin stabilized -- Ajinomoto
glial growth factor 2 -- CeNeS	haemoglobin, recombinant -- Apex
GLP-1 -- Amylin, Suntory, TheraTech, Watson	HAF -- Immune Response
GLP-1 peptide analogues -- Zealand Pharmaceuticals	Hantavirus vaccine
glucagon -- Eli Lilly, ZymoGenetics	HB 19
Glucagon-like peptide-1 7-36 amide -- Suntory	HBNF -- Regeneron
Glucocerebrosidase -- Genzyme	HCC-1 -- Pharis
glutamate decarboxylase -- Genzyme Transgenics	hCG -- Milkhaus
Glycoprotein S3 -- Kureha	hCG vaccine -- Zonagen
GM-CSF -- Immunex	HE-317 -- Hollis-Eden Pharmaceuticals
GM-CSF tumour vaccine -- PowderJect	Heat shock protein cancer and influenza vaccines -- StressGen
GnRH immunotherapeutic -- Protherics	Helicobacter pylori vaccine -- Acambis, AstraZeneca/CSL, Chiron, Provalis
gp75 antigen -- ImClone	Helistat-G -- GalaGen
gp96 -- Antigenics	Hemolink -- Hemosol
GPI 0100 -- Galenica	hepapoietin -- Snow Brand
GR 4991W93 -- GlaxoSmithKline	heparanase -- InSight
Granulocyte colony-stimulating factor -- Dong-A	heparinase I -- Ibex
Granulocyte colony-stimulating factor conjugate	heparinase III -- Ibex
grass allergy therapy -- Dynavax	Hepatitis A vaccine -- American Biogenetic Sciences
GRF1-44 -- ICN	Hepatitis A vaccine inactivated
Growth Factor -- Chiron, Atrigel, Atrix, Innogenetics, ZymoGenetics, Novo	Hepatitis A vaccine Nothav -- Chiron
growth factor peptides -- Biotherapeutics	Hepatitis A-hepatitis B vaccine -- GlaxoSmithKline
growth hormone -- LG Chem	hepatitis B therapy -- Tripep
growth hormone, Recombinant human -- Serono	Hepatitis B vaccine -- Amgen, Chiron SpA, Meiji Milk, NIS, Prodeva, PowderJect, Rhein Biotech
GT 4086 -- Gliatech	Hepatitis B vaccine recombinant -- Evans Vaccines, Epitec Combiotech, Genentech, MedImmune, Merck Sharp & Dohme, Rhein Biotech, Shantha Biotechnics, Vector, Yeda
GW 353430 -- GlaxoSmithKline	
GW-278884 -- GlaxoSmithKline	
H 11 -- Viventia Biotech	

FIG. 1L

Hepatitis B vaccine recombinant TGP 943 -- Takeda	HIV peptides -- American Home Products
Hepatitis C vaccine -- Bavarian Nordic, Chiron, Innogenetics Acambis,	HIV vaccine -- Applied bioTech., Axis Genetics, Biogen, Bristol-Myers Squibb, Genentech, Korea Green Cross, NIS, Oncogen, Protein Sciences Corporation, Terumo, Tonen Corporation, Wyeth-Ayerst, Wyeth-Lederle Vaccines-Malvern, Advanced BioScience Laboratories, Bavarian Nordic, Bavarian Nordic/Statens Serum Institute, GeneCure, Immune Response, Progenics, Therion Biologics, United Biomedical, Chiron
Hepatitis D vaccine -- Chiron Vaccines	
Hepatitis E vaccine recombinant -- Genelabs/GlaxoSmithKline, Novavax	
hepatocyte growth factor -- Panorama, Sosei	
hepatocyte growth factor kringle fragments - - EntreMed	
Her-2/Neu peptides -- Corixa	
Herpes simplex glycoprotein DNA vaccine -- Merck, Wyeth-Lederle Vaccines-Malvern, Genentech, GlaxoSmithKline, Chiron, Takeda	HIV vaccine vCP1433 -- Aventis Pasteur
Herpes simplex vaccine -- Cantab Pharmaceuticals, CEL-SCI, Henderson Morley	HIV vaccine vCP1452 -- Aventis Pasteur
Herpes simplex vaccine live -- ImClone Systems/Wyeth-Lederle, Aventis Pasteur	HIV vaccine vCP205 -- Aventis Pasteur
HGF derivatives -- Dompe	HL-9 -- American BioScience
hIAPP vaccine -- Crucell	HM-9239 -- Cytran
Hib-hepatitis B vaccine -- Aventis Pasteur	HML-103 -- Hemosol
HIC 1	HML-104 -- Hemosol
HIP-- Altachem	HML-105 -- Hemosol
Hirudins -- Biopharma, Cangene, Dongkook, Japan Energy Corporation, Pharmacia Corporation, SIR International, Sanofi-Synthelabo, Sotragene, Rhein Biotech	HML-109 -- Hemosol
HIV edible vaccine -- ProdiGene	HML-110 -- Hemosol
HIV gp120 vaccine -- Chiron, Ajinomoto, GlaxoSmithKline, ID Vaccine, Progenics, VaxGen	HML-121 -- Hemosol
HIV gp120 vaccine gene therapy --	hNLP -- Pharis
HIV gp160 DNA vaccine -- PowderJect, Aventis Pasteur, Oncogen, Hyland Immuno, Protein Sciences	Hookworm vaccine
HIV gp41 vaccine -- Panacos	host-vector vaccines -- Henogen
HIV HGP-30W vaccine -- CEL-SCI	HPM 1 -- Chugai
HIV immune globulin -- Abbott, Chiron	HPV vaccine -- MediGene
	HSA -- Meristem
	HSF -- StressGen
	HSP carriers -- Weizmann, Yeda, Peptor
	HSPPC-70 -- Antigenics
	HSPPC-96 -- pathogen-derived -- Antigenics
	HSV 863 -- Novartis
	HTLV-I DNA vaccine
	HTLV-I vaccine
	HTLV-II vaccine -- Access
	HU 901 -- Tanox
	Hu23F2G -- ICOS
	HuHMFG1

FIG. 1M



HumaLYM -- Intracell	HuMax-IL15 -- Genmab
Human krebs statika -- Yamanouchi	HYB 190 -- Hybridon
human monoclonal antibodies --	HYB 676 -- Hybridon
Abgenix/Biogen, Abgenix/ Corixa,	I-125 MAb A33 -- Celltech
Abgenix/Immunex, Abgenix/Lexicon,	Ibritumomab tiuxetan -- IDEC
Abgenix/ Pfizer, Athersys/Medarex,	IBT-9401 -- Ibex
Biogen/MorphoSys, CAT/Searle,	IBT-9402 -- Ibex
Centocor/Medarex, Corixa/Kirin Brewery,	IC 14 -- ICOS
Corixa/Medarex, Eos BioTech./Medarex,	Idarubicin anti-Ly-2.1 --
Eos/Xenerex, Exelixis/Protein Design	IDEC 114 -- IDEC
Labs, ImmunoGen/ Raven,	IDEC 131 -- IDEC
Medarex/B.Twelve,	IDEC 152 -- IDEC
MorphoSys/ImmunoGen, XTL	IDM 1 -- IDM
Blopharmaceuticals/Dyax,	IDPS -- Hollis-Eden Pharmaceuticals
Human monoclonal antibodies --	iduronate-2-sulfatase -- Transkaryotic
Medarex/Northwest Biotherapeutics,	Therapies
Medarex/Seattle Genetics	IGF/IBP-2-13 -- Pharis
human netrin-1 -- Exelixis	IGN-101 -- Igeneon
human papillomavirus antibodies -- Epicyte	IK HIR02 -- Iketon
Human papillomavirus vaccine -- Biotech	IL-11 -- Genetics Institute/AHP
Australia, IDEC, StressGen	IL-13-PE38 -- NeoPharm
Human papillomavirus vaccine MEDI 501 --	IL-17 receptor -- Immunex
MedImmune/GlaxoSmithKline	IL-18BP -- Yeda
Human papillomavirus vaccine MEDI	IL-1Hy1 -- Hyseq
503/MEDI 504 --	IL-1 $\beta$ -- Celltech
MedImmune/GlaxoSmithKline	IL-1 $\beta$ adjuvant -- Celltech
Human papillomavirus vaccine TA-CIN --	IL-2 -- Chiron
Cantab Pharmaceuticals	IL-2 + IL-12 -- Hoffman La-Roche
Human papillomavirus vaccine TA-HPV --	IL-6/sIL-6R fusion -- Hadasit
Cantab Pharmaceuticals	IL-6R derivative -- Tosoh
Human papillomavirus vaccine TH-GW --	IL-7-Dap 389 fusion toxin -- Ligand
Cantab/GlaxoSmithKline	IM-862 -- Cytran
human polyclonal antibodies -- Biosite/Eos	IMC-1C11 -- ImClone
BioTech./ Medarex	imiglucerase -- Genzyme
human type II anti factor VIII monoclonal	Immune globulin intravenous (human) --
antibodies -- ThromboGenics	Hoffman La Roche
humanised anti glycoprotein Ib murine	immune privilege factor -- Proneuron
monoclonal antibodies -- ThromboGenics	Immunocal -- Immunotec
HumaRAD -- Intracell	Immunogene therapy -- Briana Bio-Tech
HuMax EGFR -- Genmab	Immunoliposomal 5-fluorodeoxyuridine-
HuMax-CD4 -- Medarex	dipalmitate --

FIG. 1N

immunosuppressant vaccine -- Aixlie	integrin antagonists -- Merck
immunotoxin -- Antisoma, NIH	interferon (Alpha2) -- SRC VB VECTOR,
ImmuRAIT-Re-188 -- Immunomedics	Viragen, Dong-A, Hoffman La-Roche,
imreg-1 -- Imreg	Genentech
infertility -- Johnson & Johnson, E-TRANS	interferon -- BioMedicines, Human Genome
Influenza virus vaccine -- Aventis Pasteur,	Sciences
Protein Sciences	interferon (Alfa-n3)—Interferon Sciences
inhibin -- Biotech Australia, Human	Intl.
Therapeutics	interferon (Alpha), Biphasix -- Helix
Inhibitory G protein gene therapy	interferon (Alpha)—Amgen, BioNative,
INKP-2001 -- InKine	Novartis, Genzyme Transgenics,
Inolimomab -- Diaclone	Hayashibara, Inhale Therapeutics
insulin -- AutoImmune, Altea, Biobras,	Systems, Medusa, Flamel, Dong-A,
BioSante, Bio-Tech. General, Chong Kun	GeneTrol, Nastech, Shantha,
Dang, Emisphere, Flamel, Provalis, Rhein	Wassermann, LG Chem, Sumitomo,
Biotech, TranXenoGen	Aventis, Behring EGIS, Pepgen, Servier,
insulin (bovine) -- Novartis	Rhein Biotech,
insulin analogue -- Eli Lilly	interferon (Alpha2A)
Insulin Aspart -- Novo Nordisk	interferon (Alpha2B) -- Enzon, Schering-
insulin detemir -- Novo Nordisk	Plough, Biogen, IDEA
insulin glargine -- Aventis	interferon (Alpha-N1) -- GlaxoSmithKline
insulin inhaled -- Inhale Therapeutics	interferon (beta) -- Rentschler, GeneTrol,
Systems, Alkermes	Meristem, Rhein Biotech, Toray, Yeda,
insulin oral -- Inovax	Daiichi, Mochida
insulin, AeroDose -- AeroGen	interferon (Beta1A) -- Serono, Biogen
insulin, AERx -- Aradigm	interferon (beta1A), inhale -- Biogen
insulin, BEODAS -- Elan	interferon ( $\beta$ 1b) -- Chiron
insulin, Biphasix -- Helix	interferon (tau) -- Pepgen
insulin, buccal -- Generex	Interferon alfacon-1 -- Amgen
insulin, I2R -- Flemington	Interferon alpha-2a vaccine
insulin, intranasal -- Bentley	Interferon Beta 1b -- Schering/Chiron,
insulin, oral -- Nobex, Unigene	InterMune
insulin, Orasome -- Endorex	Interferon Gamma -- Boehringer Ingelheim,
insulin, ProMaxx -- Epic	Sheffield, Rentschler, Hayashibara
insulin, Quadrant -- Elan	interferon receptor, Type I -- Serono
insulin, recombinant -- Aventis	interferon(Gamma1B) -- Genentech
insulin, Spiros -- Elan	Interferon-alpha-2b + ribavirin -- Biogen,
insulin, Transfersome -- IDEA	ICN
insulin, Zymo, recombinant -- Novo Nordisk	Interferon-alpha-2b gene therapy --
insulinotropin -- Scios	Schering-Plough
Insulysin gene therapy --	Interferon-con1 gene therapy --

FIG. 10

interleukin-1 antagonists -- Dompe	IPF -- Metabolex
Interleukin-1 receptor antagonist -- Abbott	IR-501 -- Immune Response
Bioresearch, Pharmacia	ISIS 9125 -- Isis Pharmaceuticals
Interleukin-1 receptor type I -- Immunex	ISURF No. 1554 -- Millennium
interleukin-1 receptor Type II -- Immunex	ISURF No. 1866 -- Iowa State Univer.
Interleukin-10 -- DNAX, Schering-Plough	ITF-1697 -- Italfarmaco
Interleukin-10 gene therapy --	IxC 162 -- Ixion
interleukin-12 -- Genetics Institute, Hoffman	J 695 -- Cambridge Antibody Tech.,
La-Roche	Genetics Inst., Knoll
interleukin-13 -- Sanofi	Jagged + FGF -- Repair
interleukin-13 antagonists -- AMRAD	JKC-362 -- Phoenix Pharmaceuticals
Interleukin-13-PE38QQR	JTP-2942 -- Japan Tobacce
interleukin-15 -- Immunex	Juman monoclonal antibodies --
interleukin-16 -- Research Corp	Medarex/Raven
interleukin-18 -- GlaxoSmithKline	K02 -- Axys Pharmaceuticals
Interleukin-1-alpha -- Immunex/Roche	Keliximab -- IDEC
interleukin-2 -- SRC VB VECTOR,	Keyhole limpet haemocyanin
Ajinomoto, Biomira	KGF -- Amgen
Interleukin-3 -- Cangene	KM 871 -- Kyowa
Interleukin-4 -- Immunology Ventures,	KPI 135 -- Scios
Sanofi Winthrop, Schering-Plough,	KPI-022 -- Scios
Immunex/ Sanofi Winthrop, Bayer, Ono	Kringle 5
interleukin-4 + TNF-Alpha -- NIH	KSB 304
interleukin-4 agonist -- Bayer	KSB-201 -- KS Biomedix
interleukin-4 fusion toxin -- Ligand	L 696418 -- Merck
Interleukin-4 receptor -- Immunex, Immun	L 703801 -- Merck
Interleukin-6 -- Ajinomoto, Cangene, Yeda,	L1 -- Acorda
Genetics Institute, Novartis	L-761191 -- Merck
interleukin-6 fusion protein --	lactoferrin -- Meristem, Pharming, Agennix
interleukin-6 fusion toxin -- Ligand, Serono	lactoferrin cardio -- Pharming
interleukin-7 -- IC Innovations	LAG-3 -- Serono
interleukin-7 receptor -- Immunex	LAIT -- GEMMA
interleukin-8 antagonists -- Kyowa	LAK cell cytotoxin -- Arizona
Hakko/Millennium/Pfizer	lamellarins -- PharmaMar/University of
interleukin-9 antagonists -- Genaera	Malaga
interleukins -- Cel-Sci	laminin A peptides -- NIH
Iodine I 131 tositumomab -- Corixa	lanotriplase -- Genetics Institute
ior EPOCIM -- Center of Molecular	laronidase -- BioMarin
Immunology	Lassa fever vaccine
lor-P3 -- Center of Molecular Immunology	LCAT -- NIH
IP-10 -- NIH	LDP 01 -- Millennium

**FIG. 1P**

LDP 02 -- Millennium	Lyme disease vaccine -- Aquila
Lecithinized superoxide dismutase -- Seikagaku	Biopharmaceuticals, Aventis, Pasteur, Symbicom, GlaxoSmithKline, Hyland
LeIF adjuvant -- Corixa	Immuno, MedImmune
leishmaniasis vaccine -- Corixa	Lymphocytic choriomeningitis virus vaccine
lenercept -- Hoffman La-Roche	lymphoma vaccine -- Biomira, Genitope
Lenograstim -- Aventis, Chugai	LYP18
lepirudin -- Aventis	lys plasminogen, recombinant
leptin -- Amgen, IC Innovations	Lysosomal storage disease gene therapy -- Avigen
Leptin gene therapy -- Chiron Corporation	lysostaphin -- Nutrition 21
leptin, 2nd-generation -- Amgen	M 23 -- Gruenenthal
leridistim -- Pharmacia	M1 monoclonal antibodies -- Acorda Therapeutics
leuprolide, ProMaxx -- Epic	MA 16N7C2 -- Corvas Intl.
leuporelin, oral -- Unigene	malaria vaccine -- GlaxoSmithKline, AdProTech, Antigenics, Apovia, Aventis
LeuTech -- Papatin	Pasteur, Axis Genetics, Behringwerke, CDCP, Chiron Vaccines, Genzyme
LEX 032 -- SuperGen	Transgenics, Hawaii, MedImmune, NIH, NYU, Oxxon, Roche/Saramane, Biotech
LiDEPT -- Novartis	Australia, Rx Tech
lipase -- Altus Biologics	Malaria vaccine CDC/NIIMALVAC-1
lipid A vaccine -- EntreMed	malaria vaccine, multicomponent
lipid-linked anchor Tech. -- ICRT, ID Biomedical	mammaglobin -- Corixa
liposome-CD4 Tech. -- Sheffield	mammastatin -- Biotherapeutics
Listeria monocytogenes vaccine	mannan-binding lectin -- NatlImmu
LMB 1	mannan-MUC1 -- Psiron
LMB 7	MAP 30
LMB 9 -- Battelle Memorial Institute, NIH	Marinovir -- Phytera
LM-CD45 -- Cantab Pharmaceuticals	MARstem -- Maret
lovastatin -- Merck	MB-015 -- Mochida
LSA-3	MBP -- ImmuLogic
LT- $\beta$ receptor -- Biogen	MCI-028 -- Mitsubishi-Tokyo
lung cancer vaccine -- Corixa	MCIF -- Human Genome Sciences
lusupultide -- Scios	MDC -- Advanced BioScience -- Akzo
L-Vax -- AVAX	Nobel, ICOS
LY 355455 -- Eli Lilly	MDX 11 -- Medarex
LY 366405 -- Eli Lilly	MDX 210 -- Medarex
LY-355101 -- Eli Lilly	MDX 22 -- Medarex
Lyme disease DNA vaccine -- Vical/Aventis	MDX 22
Pasteur	

FIG. 1Q

MDX 240 -- Medarex	Methionine lyase gene therapy --
MDX 33	AntiCancer
MDX 44 -- Medarex	Met-RANTES -- Genexa Biomedical,
MDX 447 -- Medarex	Serono
MDX H210 -- Medarex	Metreleptin
MDX RA -- Houston BioTech., Medarex	MGDF -- Kirin
ME-104 -- Pharmexa	MGV -- Progenics
Measles vaccine	micrin -- Endocrine
Mecasermin -- Cephalon/Chiron, Chiron	microplasmin -- ThromboGenics
MEDI 488 -- MedImmune	MIF -- Genetics Institute
MEDI 500	migration inhibitory factor -- NIH
MEDI 507 -- BioTransplant	Mim CD4.1 -- Xycte Therapies
melanin concentrating hormone --	mirostipen -- Human Genome Sciences
Neurocrine Biosciences	MK 852 -- Merck
melanocortins -- OMRF	Mobenakin -- NIS
Melanoma monoclonal antibodies -- Viragen	molgramostim -- Genetics Institute, Novartis
melanoma vaccine -- GlaxoSmithKline,	monoclonal antibodies -- Abgenix/Celltech,
Akzo Nobel, Avant, Aventis Pasteur,	Immusol/ Medarex, Viragen/ Roslin
Bavarian Nordic, Biovector, CancerVax,	Institute, Cambridge Antibody Tech./Elan
Genzyme Molecular Oncology, Humbolt,	MAb 108 --
ImClone Systems, Memorial, NYU, Oxxon	MAb 10D5 --
Melanoma vaccine Magevac -- Therion	MAb 14.18-interleukin-2 immunocytokine --
memory enhancers -- Scios	Lexigen
meningococcal B vaccine -- Chiron	MAb 14G2a --
meningococcal vaccine -- CAMR	MAb 15A10 --
Meningococcal vaccine group B conjugate -	MAb 170 -- Biomira
- North American Vaccine	MAb 177Lu CC49 --
Meningococcal vaccine group B	MAb 17F9
recombinant -- BioChem Vaccines,	MAb 1D7
Microscience	MAb 1F7 -- Immune Network
Meningococcal vaccine group Y conjugate -	MAb 1H10-doxorubicin conjugate
- North American Vaccine	MAb 26-2F
Meningococcal vaccine groups A B and C	MAb 2A11
conjugate -- North American Vaccine	MAb 2E1 -- RW Johnson
Mepolizumab -- GlaxoSmithKline	MAb 2F5
Metastatin -- EntreMed, Takeda	MAb 31.1 -- International BioImmune
Met-CkB7 -- Human Genome Sciences	Systems
met-enkephalin -- TNI	MAb 32 -- Cambridge Antibody Tech.,
METH-1 -- Human Genome Sciences	Peptech
methioninase -- AntiCancer	MAb 323A3 -- Centocor
	MAb 3C5

FIG. 1R

MAb 3F12	MAb C242-PE conjugate
MAb 3F8	MAb c30-6
MAb 42/6	MAb CA208-cytorhodin-S conjugate --
MAb 425 -- Merck KGaA	Hoechst Japan
MAb 447-52D -- Merck Sharp & Dohme	MAb CC49 -- Enzon
MAb 45-2D9- -- haematoporphyrin	MAb ch14.18 --
conjugate	MAb CH14.18-GM-CSF fusion protein --
MAb 4B4	Lexigen
MAb 4E3-CPA conjugate -- BCM Oncologia	MAb chCE7
MAb 4E3-daunorubicin conjugate	MAb CI-137 -- AMRAD
MAb 50-6	MAb cisplatin conjugate
MAb 50-61A -- Institut Pasteur	MAb CLB-CD19
MAb 5A8 -- Biogen	MAb CLB-CD19v
MAb 791T/36-methotrexate conjugate	MAb CLL-1 -- Peregrine
MAb 7c11.e8	MAb CLL-1-GM-CSF conjugate
MAb 7E11 C5-selenocystamine conjugate	MAb CLL-1-IL-2 conjugate -- Peregrine
MAb 93KA9 -- Novartis	MAb CLN IgG -- doxorubicin conjugates
MAb A5B7-cisplatin conjugate --	MAb conjugates -- Tanox
Biodynamics Research, Pharmacia	MAb D612
MAb A5B7-I-131	MAb Dal B02
MAb A7	MAb DC101 -- ImClone
MAb A717 -- Exocell	MAb EA 1 --
MAb A7-zinostatin conjugate	MAb EC708 -- Biovation
MAb ABX-RB2 -- Abgenix	MAb EP-5C7 -- Protein Design Labs
MAb ACA 11	MAb ERIC-1 -- ICRT
MAb AFP-I-131 -- Immunomedics	MAb F105 gene therapy
MAb AP1	MAb FC 2.15
MAb AZ1	MAb G250 -- Centocor
MAb B3-LysPE40 conjugate	MAb GA6
MAb B4 -- United Biomedical	MAb GA733
MAb B43 Genistein-conjugate	MAb Gliomab-H -- Viventia Biotech
MAb B43.13-Tc-99m -- Biomira	MAb HB2-saporin conjugate
MAb B43-PAP conjugate	MAb HD 37 --
MAb B4G7-gelonin conjugate	MAb HD37-ricin chain-A conjugate
MAb BCM 43-daunorubicin conjugate --	MAb HNK20 -- Acambis
BCM Oncologia	MAb huN901-DM1 conjugate --
MAb BIS-1	ImmunoGen
MAb BMS 181170 -- Bristol-Myers Squibb	MAb I-131 CC49 -- Corixa
MAb BR55-2	MAb ICO25
MAb BW494	MAb ICR12-CPG2 conjugate
MAb C 242-DM1 conjugate -- ImmunoGen	MAb ICR-62

FIG. 1S

MAb IRac-ricin A conjugate	MAb R-24
MAb K1	MAb R-24 $\alpha$ Human GD3 -- Celltech
MAb KS1-4-methotrexate conjugate	MAb RFB4-ricin chain A conjugate
MAb L6 -- Bristol-Myers Squibb, Oncogen	MAb RFT5-ricin chain A conjugate
MAb LiCO 16-88	MAb SC 1
MAb LL2-I-131 -- Immunomedics	MAb SM-3 -- ICRT
MAb LL2-Y-90	MAb SMART 1D10 -- Protein Design Labs
MAb LS2D617 -- Hybritech	MAb SMART ABL 364 -- Novartis
MAb LYM-1-gelonin conjugate	MAb SN6f
MAb LYM-1-I-131	MAb SN6f-deglycosylated ricin A chain
MAb LYM-1-Y-90	conjugate --
MAb LYM-2 -- Peregrine	MAb SN6j
MAb M195	MAb SN7-ricin chain A conjugate
MAb M195-bismuth 213 conjugate --	MAb T101-Y-90 conjugate -- Hybritech
Protein Design Labs	MAb T-88 -- Chiron
MAb M195-gelonin conjugate	MAb TB94 -- Cancer ImmunoBiology
MAb M195-I-131	MAb TEC 11
MAb M195-Y-90	MAb TES-23 -- Chugai
MAb MA 33H1 -- Sanofi	MAb TM31 -- Avant
MAb MAD11	MAb TNT-1 -- Cambridge Antibody Tech.,
MAb MGB2	Peregrine
MAb MINT5	MAb TNT-3
MAb MK2-23	MAb TNT-3 -- IL2 fusion protein --
MAb MOC31 ETA(252-613) conjugate	MAb TP3-At-211
MAb MOC-31-In-111	MAb TP3-PAP conjugate --
MAb MOC-31-PE conjugate	MAb UJ13A -- ICRT
MAb MR6 --	MAb UN3
MAb MRK-16 -- Aventis Pasteur	MAb ZME-018-gelonin conjugate
MAb MS11G6	MAb-BC2 -- GlaxoSmithKline
MAb MX-DTPA BrE-3	MAb-DM1 conjugate -- ImmunoGen
MAb MY9	MAb-ricin-chain-A conjugate -- XOMA
MAb Nd2 -- Tosoh	MAb-temoporfin conjugates
MAb NG-1 -- Hygeia	Monopharm C -- Viventia Biotech
MAb NM01 -- Nissin Food	monteplase -- Eisai
MAb OC 125	montirelin hydrate -- Gruenenthal
MAb OC 125-CMA conjugate	moroctocog alfa -- Genetics Institute
MAb OKI-1 -- Ortho-McNeil	Moroctocog-alfa -- Pharmacia
MAb OX52 -- Bioproducts for Science	MP 4
MAb PMA5	MP-121 -- Biopharm
MAb PR1	MP-52 -- Biopharm
MAb prost 30	MRA -- Chugai

**FIG. 1T**

MS 28168 -- Mitsui Chemicals, Nihon Schering	Neuroprotective vaccine -- University of Auckland
MSH fusion toxin -- Ligand	neurotrophic chimaeras -- Regeneron
MSI-99 -- Genaera	neurotrophic factor -- NsGene, CereMedix
MT 201 -- Micromet	NeuroVax -- Immune Response
Muc-1 vaccine -- Corixa	neurturin -- Genentech
mucosal tolerance -- Aberdeen	neutral endopeptidase -- Genentech
mullerian inhibiting subst	NGF enhancers -- NeuroSearch
muplestim -- Genetics Institute, Novartis, DSM Anti-Infectives	NHL vaccine -- Large Scale Biology
murine MAb -- KS Biomedix	NIP45 -- Boston Life Sciences
Mutant somatropin -- JCR Pharmaceutical	NKI-B20
MV 833 -- Toagosei	NM 01 -- Nissin Food
Mycoplasma pulmonis vaccine	NMI-139 -- NitroMed
Mycoprex -- XOMA	NMMP -- Genetics Institute
myeloperoxidase -- Henogen	NN-2211 -- Novo Nordisk
myostatin -- Genetics Institute	Noggin -- Regeneron
Nacolomab tafenatox -- Pharmacia	Nonacog alfa
nagrestipen -- British Biotech	Norelin -- Biostar
NAP-5 -- Corvas Intl.	Norwalk virus vaccine
NAPc2 -- Corvas Intl.	NRLU 10 -- NeoRx
nartograstim -- Kyowa	NRLU 10 PE -- NeoRx
Natalizumab -- Protein Design Labs	NT-3 -- Regeneron
Nateplase -- NIH, Nihon Schering	NT-4/5 -- Genentech
nateplase -- Schering AG	NU 3056
NBI-3001 -- Neurocrine Biosci.	NU 3076
NBI-5788 -- Neurocrine Biosci.	NX 1838 -- Gilead Sciences
NBI-6024 -- Neurocrine Biosci.	NY ESO-1/CAG-3 antigen -- NIH
Nef inhibitors -- BRI	NYVAC-7 -- Aventis Pasteur
Neisseria gonorrhoea vaccine -- Antex Biologics	NZ-1002 -- Novazyme
Neomycin B-arginine conjugate	obesity therapy -- Nobex
Nerelimomab -- Chiron	OC 10426 -- Ontogen
Nerve growth factor -- Amgen -- Chiron, Genentech	OC 144093 -- Ontogen
Nerve growth factor gene therapy	OCIF -- Sankyo
nesiritide citrate -- Scios	Oct-43 -- Otsuka
neuregulin-2 -- CeNeS	OK PSA - liposomal
neurocan -- NYU	OKT3-gamma-1-ala-ala
neuronal delivery system -- CAMR	OM 991
	OM 992
	Omalizumab -- Genentech
	oncoimmunin-L -- NIH
	Oncolysin B -- ImmunoGen

**FIG. 1U**



Oncolysin CD6 -- ImmunoGen	PAM 4 -- Merck
Oncolysin M -- ImmunoGen	pamiteplase -- Yamanouchi
Oncolysin S -- ImmunoGen	pancreatin, Minitabs -- Eurand
Oncophage -- Antigenics	Pangen -- Fournier
Oncostatin M -- Bristol-Myers Squibb	Pantarin -- Selective Genetics
OncoVax-CL -- Jenner Biotherapies	Parainfluenza virus vaccine -- Pharmacia,
OncoVax-P -- Jenner Biotherapies	Pierre Fabre
onercept -- Yeda	paraoxanase -- Esperion
onychomycosis vaccine -- Boehringer	parathyroid hormone -- Abiogen, Korea
Ingelheim	Green Cross
opebecan -- XOMA	Parathyroid hormone (1-34) --
opioids -- Arizona	Chugai/Suntory
Oprelvekin -- Genetics Institute	Parkinson's disease gene therapy -- Cell
Org-33408 b-- Akzo Nobel	Genesys/ Ceregene
Orolip DP -- EpiCept	Parvovirus vaccine -- MedImmune
oryzacystatin	PCP-Scan -- Immunomedics
OSA peptides -- GenSci Regeneration	PDGF cocktail -- Theratechnologies
osteoblast-cadherin GF -- Pharis	peanut allergy therapy -- Dynavax
Osteocalcin-thymidine kinase gene therapy	PEG anti-ICAM MAb -- Boehringer
osteogenic protein -- Curis	Ingelheim
osteopontin -- OraPharma	PEG asparaginase -- Enzon
osteoporosis peptides -- Integra, Telios	PEG glucocerebrosidase
osteoprotegerin -- Amgen, SnowBrand	PEG hirudin -- Knoll
otitis media vaccines -- Antex Biologics	PEG interferon-alpha-2a -- Roche
ovarian cancer -- University of Alabama	PEG interferon-alpha-2b + ribavirin --
OX40-IgG fusion protein -- Cantab, Xenova	Biogen, Enzon, ICN Pharmaceuticals,
P 246 -- Diatide	Schering-Plough
P 30 -- Alfacell	PEG MAb A5B7 --
p1025 -- Active Biotech	Pegacaristim -- Amgen -- Kirin Brewery --
P-113 <sup>^</sup> -- Demegen	ZymoGenetics
P-16 peptide -- Transition Therapeutics	Pegaldesleukin -- Research Corp
p43 -- Ramot	pegaspargase -- Enzon
P-50 peptide -- Transition Therapeutics	pegfilgrastim -- Amgen
p53 + RAS vaccine -- NIH, NCI	PEG-interferon Alpha -- Viragen
PACAP(1-27) analogue	PEG-interferon Alpha 2A -- Hoffman La-
paediatric vaccines -- Chiron	Roche
Pafase -- ICOS	PEG-interferon Alpha 2B -- Schering-
PAGE-4 plasmid DNA -- IDEC	Plough
PAI-2 -- Biotech Australia, Human	PEG-r-hirudin -- Abbott
Therapeutics	PEG-uricase -- Mountain View
Palivizumab -- MedImmune	Pegvisomant -- Genentech

FIG. 1V

PEGylated proteins, PolyMASC -- Valentis Pharmaprojects No. 5947 -- StressGen  
 PEGylated recombinant native human leptin Pharmaprojects No. 5961 --  
 -- Roche  
 Theratechnologies  
 Pemtumomab Pharmaprojects No. 5962 -- NIH  
 Penetratin -- Cyclacel Pharmaprojects No. 5966 -- NIH  
 Pepscan -- Antisoma Pharmaprojects No. 5994 -- Pharming  
 peptide G -- Peptech, ICRT Pharmaprojects No. 5995 -- Pharming  
 peptide vaccine -- NIH ,NCI Pharmaprojects No. 6023 -- IMMUCON  
 Pexelizumab Pharmaprojects No. 6063 -- Cytoclonal  
 pexiganan acetate -- Genaera Pharmaprojects No. 6073 -- SIDDCO  
 Pharmaprojects No. 3179 -- NYU Pharmaprojects No. 6115 -- Genzyme  
 Pharmaprojects No. 3390 -- Ernest Orlando Pharmaprojects No. 6227 -- NIH  
 Pharmaprojects No. 3417 -- Sumitomo Pharmaprojects No. 6230 -- NIH  
 Pharmaprojects No. 3777 -- Acambis Pharmaprojects No. 6236 -- NIH  
 Pharmaprojects No. 4209 -- XOMA Pharmaprojects No. 6243 -- NIH  
 Pharmaprojects No. 4349 -- Baxter Intl. Pharmaprojects No. 6244 -- NIH  
 Pharmaprojects No. 4651 Pharmaprojects No. 6281 -- Senetek  
 Pharmaprojects No. 4915 -- Avanir Pharmaprojects No. 6365 -- NIH  
 Pharmaprojects No. 5156 -- Rhizogenics Pharmaprojects No. 6368 -- NIH  
 Pharmaprojects No. 5200 -- Pfizer Pharmaprojects No. 6373 -- NIH  
 Pharmaprojects No. 5215 -- Origene Pharmaprojects No. 6408 -- Pan Pacific  
 Pharmaprojects No. 5216 -- Origene Pharmaprojects No. 6410 -- Athersys  
 Pharmaprojects No. 5218 -- Origene Pharmaprojects No. 6421 -- Oxford  
 Pharmaprojects No. 5267 -- ML  
 GlycoSciences  
 Laboratories Pharmaprojects No. 6522 -- Maxygen  
 Pharmaprojects No. 5373 -- MorphoSys Pharmaprojects No. 6523 -- Pharis  
 Pharmaprojects No. 5493 -- Metabolex Pharmaprojects No. 6538 -- Maxygen  
 Pharmaprojects No. 5707 -- Genentech Pharmaprojects No. 6554 -- APALEXO  
 Pharmaprojects No. 5728 -- Autogen Pharmaprojects No. 6560 -- Ardana  
 Pharmaprojects No. 5733 -- BioMarin Pharmaprojects No. 6562 -- Bayer  
 Pharmaprojects No. 5757 -- NIH Pharmaprojects No. 6569 -- Eos  
 Pharmaprojects No. 5765 -- Gryphon Phenoxazine  
 Pharmaprojects No. 5830 -- AntiCancer Phenylase -- Ibex  
 Pharmaprojects No. 5839 -- Dyax Pigment epithelium derived factor --  
 Pharmaprojects No. 5849 -- Johnson & plasminogen activator inhibitor-1,  
 Johnson recombinant -- DuPont Pharmaceuticals  
 Pharmaprojects No. 5860 -- Mitsubishi-  
 Tokyo  
 Pharmaprojects No. 5869 -- Oxford  
 GlycoSciences  
 Pharmaprojects No. 5883 -- Asahi Brewery

FIG. 1W

Plasminogen activators -- Abbott Laboratories, American Home Products, Boehringer Mannheim, Chiron Corporation, DuPont Pharmaceuticals, Eli Lilly, Shionogi, Genentech, Genetics Institute, GlaxoSmithKline, Hemispherx Biopharma, Merck & Co, Novartis, Pharmacia Corporation, Wakamoto, Yeda	prostate-specific antigen -- EntreMed
plasminogen-related peptides -- Bio-Tech. General/MGH	protein A -- RepliGen
platelet factor 4 -- RepliGen	protein adhesives -- Enzon
Platelet-derived growth factor -- Amgen -- ZymoGenetics	protein C -- Baxter Intl., PPL Therapeutics, ZymoGenetics
plusonemin-- Hayashibara	protein C activator -- Gilead Sciences
PMD-2850 -- Protherics	protein kinase R antags -- NIH
Pneumococcal vaccine -- Antex Biologics, Aventis Pasteur	protirelin -- Takeda
Pneumococcal vaccine intranasal -- BioChem Vaccines/Biovector	protocadherin 2 -- Caprion
PR1A3	Pro-urokinase -- Abbott, Bristol-Myers Squibb, Dainippon, Tosoh -- Welfide
PR-39	P-selectin glycoprotein ligand-1 -- Genetics Institute
pralmorelin -- Kaken	pseudomonal infections -- InterMune
Pretarget-Lymphoma -- NeoRx	Pseudomonas vaccine -- Cytovax
Priliximab -- Centocor	PSGL-Ig -- American Home Products
PRO 140 -- Progenics	PSP-94 -- Procyon
PRO 2000 -- Procept	PTH 1-34 -- Nobex
PRO 367 -- Progenics	Quilimmune-M -- Antigenics
PRO 542 -- Progenics	R 101933
pro-Apo A-I -- Esperion	R 125224 -- Sankyo
prolactin -- Genzyme	RA therapy -- Cardion
Prosaptide TX14(A) -- Bio-Tech. General	Rabies vaccine recombinant -- Aventis Pasteur, BioChem Vaccines, Kaketsuken Pharmaceuticals
prostate cancer antibodies -- Immunex, UroCor	RadioTheraCIM -- YM BioSciences
prostate cancer antibody therapy -- Genentech/UroGenesys, Genotherapeutics	Ramot project No. 1315 -- Ramot
prostate cancer immunotherapeutics -- The PSMA Development Company	Ramot project No. K-734A -- Ramot
prostate cancer vaccine -- Aventis Pasteur, Zonagen, Corixa, Dendreon, Jenner Biotherapies, Therion Biologics	Ramot project No. K-734B -- Ramot
	RANK -- Immunex
	ranpirinase -- Alfacell
	ranpirinase-anti-CD22 MAb -- Alfacell
	RANTES inhibitor -- Milan
	RAPID drug delivery systems -- ARIAD
	rasburicase -- Sanofi
	rBPI-21, topical -- XOMA
	RC 529 -- Corixa
	rCFTR -- Genzyme Transgenics
	RD 62198
	rDnase -- Genentech
	RDP-58 -- SangStat

**FIG. 1X**

RecepTox-Fce -- Keryx	Ribozyme gene therapy -- Genset
RecepTox-GnRH -- Keryx, MTR Technologies	Rickettsial vaccine recombinant
RecepTox-MBP -- Keryx, MTR Technologies	RIGScan CR -- Neoprobe
recFSH -- Akzo Nobel, Organon	RIP-3 -- Rigel
REGA 3G12	RK-0202 -- RxKinetix
Regavirumab -- Teijin	RLT peptide -- Esperion
relaxin -- Connetics Corp	rM/NEI -- IVAX
Renal cancer vaccine -- Macropharm	rmCRP -- Immtech
repifermin -- Human Genome Sciences	RN-1001 -- Renovo
Respiratory syncytial virus PFP-2 vaccine -- Wyeth-Lederle	RN-3 -- Renovo
Respiratory syncytial virus vaccine -- GlaxoSmithKline, Pharmacia, Pierre Fabre	RNAse conjugate -- Immunomedics
Respiratory syncytial virus vaccine inactivated	RO 631908 -- Roche
Respiratory syncytial virus-parainfluenza virus vaccine -- Aventis Pasteur, Pharmacia	Rotavirus vaccine -- Merck
Retepase -- Boehringer Mannheim, Hoffman La-Roche	RP 431 -- DuPont Pharmaceuticals
Retropep -- Retroscreen	RP-128 -- Resolution
RFB4 (dsFv) PE38	RPE65 gene therapy --
RFI 641 -- American Home Products	RPR 110173 -- Aventis Pasteur
RFTS -- UAB Research Foundation	RPR 115135 -- Aventis Pasteur
RG 12986 -- Aventis Pasteur	RPR 116258A -- Aventis Pasteur
RG 83852 -- Aventis Pasteur	rPSGL-Ig -- American Home Products
RG-1059 -- RepliGen	r-SPC surfactant -- Byk Gulden
rGCR -- NIH	rV-HER-2/neu -- Therion Biologics
rGLP-1 -- Restoragen	SA 1042 -- Sankyo
rGRF -- Restoragen	sacrosidase -- Orphan Medical
rh Insulin -- Eli Lilly	Sant 7
RHAMM targeting peptides -- Cangene	Sargramostim -- Immunex
rHb1.1 -- Baxter Intl.	saruplase -- Gruenenthal
rhCC10 -- Claragen	Satumomab -- Cytogen
rhCG -- Serono	SB 1 -- COR Therapeutics
Rheumatoid arthritis gene therapy	SB 207448 -- GlaxoSmithKline
Rheumatoid arthritis vaccine -- Veterans Affairs Medical Center	SB 208651 -- GlaxoSmithKline
rhLH -- Serono	SB 240683 -- GlaxoSmithKline
	SB 249415 -- GlaxoSmithKline
	SB 249417 -- GlaxoSmithKline
	SB 6 -- COR Therapeutics
	SB RA 31012 --
	SC 56929 -- Pharmacia
	SCA binding proteins -- Curis, Enzon
	scFv(14E1)-ETA Berlex Laboratories, Schering AG
	ScFv(FRP5)-ETA --

FIG. 1Y

ScFv6C6-PE40 --	somatomedin-1 -- GroPep, Mitsubishi-Tokyo, NIH
SCH 55700 -- Celltech	somatomedin-1 carrier protein -- Insmad
Schistosomiasis vaccine -- Glaxo Wellcome/Medeva, Brazil	somatostatin -- Ferring
SCPF -- Advanced Tissue Sciences	Somatotropin/
scuPA-suPAR complex -- Hadasit	Human Growth Hormone -- Bio-Tech. General, Eli Lilly
SD-9427 -- Pharmacia	somatropin -- Bio-Tech. General, Alkermes, ProLease, Aventis Behring, Biovector, Cangene, Dong-A, Eli Lilly, Emisphere, Enact, Genentech, Genzyme Transgenics, Grandis/InfiMed, CSL, InfiMed, MacroMed, Novartis, Novo Nordisk, Pharmacia Serono, TranXenoGen
SDF-1 -- Ono	somatropin derivative -- Schering AG
SDZ 215918 -- Novartis	somatropin, AIR -- Eli Lilly
SDZ 280125 -- Novartis	Somatropin, inhaled -- Eli Lilly/Alkermes
SDZ 89104 -- Novartis	somatropin, Kabi -- Pharmacia
SDZ ABL 364 -- Novartis	somatropin, Orasome -- Novo Nordisk
SDZ MMA 383 -- Novartis	Sonermin -- Dainippon Pharmaceutical
serine protease inhbs -- Pharis	SP(V5.2)C -- Supertek
sermorelin acetate -- Serono	SPf66
SERP-1 -- Viron	sphingomyelinase -- Genzyme
sertenef -- Dainippon	SR 29001 -- Sanofi
serum albumin, Recombinant human -- Aventis Behring	SR 41476 -- Sanofi
serum-derived factor -- Hadasit	SR-29001 -- Sanofi
Sevirumab -- Novartis	SS1(dsFV)-PE38 -- NeoPharm
SGN 14 -- Seattle Genetics	$\beta$ 2 microglobulin -- Avidex
SGN 15 -- Seattle Genetics	$\beta$ 2-microglobulin fusion proteins -- NIH
SGN 17/19 -- Seattle Genetics	$\beta$ -amyloid peptides -- CeNeS
SGN 30 -- Seattle Genetics	$\beta$ -defensin -- Pharis
SGN-10 -- Seattle Genetics	Staphylococcus aureus infections -- Inhibitex/ZLB
SGN-11 -- Seattle Genetics	Staphylococcus aureus vaccine conjugate -- Nabi
SH 306 -- DuPont Pharmaceuticals	Staphylococcus therapy -- Tripep
Shanvac-B -- Shantha	Staphylokinase -- Biovation, Prothera, Thrombogenetics
Shigella flexneri vaccine -- Avant, Acambis, Novavax	Streptococcal A vaccine -- M6 Pharmaceuticals, North American Vaccine
Shigella sonnei vaccine --	Streptococcal B vaccine -- Microscience
sICAM-1 -- Boehringer Ingelheim	
Silteplase -- Genzyme	
SIV vaccine -- Endocon, Institut Pasteur	
SK 896 -- Sanwa Kagaku Kenkyusho	
SK-827 -- Sanwa Kagaku Kenkyusho	
Skeletex -- CellFactors	
SKF 106160 -- GlaxoSmithKline	
S-nitroso-AR545C --	
SNTP -- Active Biotech	

FIG. 1Z

Streptococcal B vaccine recombinant -- Biochem Vaccines	TFPI -- EntreMed
Streptococcus pyogenes vaccine	tgD-IL-2 -- Takeda
STRL-33 -- NIH	TGF-Alpha -- ZymoGenetics
Subalin -- SRC VB VECTOR	TGF- $\beta$ -- Kolon
SUIS -- United Biomedical	TGF- $\beta$ 2 -- Insmmed
SUIS-LHRH -- United Biomedical	TGF- $\beta$ 3 -- OSI
SUN-E3001 -- Suntory	Thalassaemia gene therapy -- Crucell
super high affinity monoclonal antibodies -- YM BioSciences	TheraCIM-h-R3 -- Center of Molecular Immunology, YM BioSciences
Superoxide dismutase -- Chiron, Enzon, Ube Industries, Bio-Tech, Yeda	Theradigm-HBV -- Epimmune
superoxide dismutase-2 -- OXIS	Theradigm-HPV -- Epimmune
suppressin -- UAB Research Foundation	Theradigm-malaria -- Epimmune
SY-161-P5 -- ThromboGenics	Theradigm-melanoma -- Epimmune
SY-162 -- ThromboGenics	TheraFab -- Antisoma
Systemic lupus erythematosus vaccine -- MedClone/VivoRx	ThGRF 1-29 -- Theratechnologies
T cell receptor peptide vaccine	ThGRF 1-44 -- Theratechnologies
T4N5 liposomes -- AGI Dermatics	thrombomodulin -- Iowa, Novocastra
TACI, soluble -- ZymoGenetics	Thrombopoietin -- Dragon Pharmaceuticals, Genentech
targeted apoptosis -- Antisoma	thrombopoietin, Pliva -- Recepton
tasonermin -- Boehringer Ingelheim	Thrombospondin 2 --
TASP	thrombostatin -- Thromgen
TASP-V	thymalfasin -- SciClone
Tat peptide analogues -- NIH	thymocartin -- Gedeon Richter
TBP I -- Yeda	thymosin Alpha1 -- NIH
TBP II	thyroid stimulating hormone -- Genzyme
TBV25H -- NIH	tICAM-1 -- Bayer
Tc 99m for cea1 -- Center of Molecular Immunology	Tick anticoagulant peptide -- Merck
Tc 99m P 748 -- Diatide	TIF -- Xoma
Tc 99m votumumab -- Intracell	Tifacogin -- Chiron, NIS, Pharmacia
Tc-99m rh-Annexin V -- Theseus Imaging	Tissue factor -- Genentech
teceleukin -- Biogen	Tissue factor pathway inhibitor
tenecteplase -- Genentech	TJN-135 -- Tsumura
Teriparatide -- Armour Pharmaceuticals, Asahi Kasei, Eli Lilly	TM 27 -- Avant
terlipressin -- Ferring	TM 29 -- Avant
testisin -- AMRAD	TMC-151 -- Tanabe Seiyaku
Tetrafibricin -- Roche	TNF tumour necrosis factor -- Asahi Kasei
	TNF Alpha -- CytImmune
	TNF antibody -- Johnson & Johnson
	TNF binding protein -- Amgen
	TNF degradation product -- Oncotech

FIG. 1AA

TNF receptor -- Immunex	TXU-PAP
TNF receptor 1, soluble -- Amgen	TY-10721 -- TOA Eiyo
TNF Tumour necrosis factor-alpha -- Asahi Kasei, Genentech, Mochida	Type I diabetes vaccine -- Research Corp
TNF-Alpha inhibitor -- Tripep	Typhoid vaccine CVD 908
TNFR:Fc gene therapy -- Targeted Genetics	U 143677 -- Pharmacia
TNF-SAM2	U 81749 -- Pharmacia
ToleriMab -- Innogenetics	UA 1248 -- Arizona
Toxoplasma gondii vaccine -- GlaxoSmithKline	UGIF -- Sheffield
TP 9201 -- Telios	UIC 2
TP10 -- Avant	UK 101
TP20 -- Avant	UK-279276 -- Corvas Intl.
tPA -- Centocor	urodilatin -- Pharis
trafermin -- Scios	urofolitrophin -- Serono
TRAIL/Apo2L -- Immunex	uteroferrin -- Pepgen
transferrin-binding proteins -- CAMR	V 20 -- GLYCODEsign
Transforming growth factor-beta-1 -- Genentech	V2 vasopressin receptor gene therapy
transport protein -- Genesis	vaccines -- Active Biotech
TRH -- Ferring	Varicella zoster glycoprotein vaccine -- Research Corporation Technologies
Triabin -- Schering AG	Varicella zoster virus vaccine live -- Cantab Pharmaceuticals
Triconal	Vascular endothelial growth factor -- Genentech, University of California
Triflavin	Vascular endothelial growth factors -- R&D Systems
troponin I -- Boston Life Sciences	vascular targeting agents -- Peregrine
TRP-2 <sup>Δ</sup> -- NIH	vasopermeation enhancement agents -- Peregrine
trypsin inhibitor -- Mochida	vasostatin -- NIH
TSP-1 gene therapy --	VCL -- Bio-Tech. General
TT-232	VEGF -- Genentech, Scios
TTS-CD2 -- Active Biotech	VEGF inhibitor -- Chugai
Tuberculosis vaccine -- Aventis Pasteur, Genesis	VEGF-2 -- Human Genome Sciences
Tumor Targeted Superantigens -- Active Biotech -- Pharmacia	VEGF-Trap -- Regeneron
tumour vaccines -- PhotoCure	viscumin, recombinant -- Madaus
tumour-activated prodrug antibody conjugates -- Millennium/ImmunoGen	Vitaxin
tumstatin -- ILEX	Vitrax -- ISTA Pharmaceuticals
Tuvirumab -- Novartis	West Nile virus vaccine -- Bavarian Nordic
TV-4710 -- Teva	WP 652
TWEAK receptor -- Immunex	WT1 vaccine -- Corixa
	WX-293 -- Willex BioTech.

**FIG. 1BB**

WX-360 -- Wilex BioTech.	YM 207 -- Yamanouchi
WX-UK1 -- Wilex BioTech.	YM 337 -- Protein Design Labs
XMP-500 -- XOMA	Yttrium-90 labelled biotin
XomaZyme-791 -- XOMA	Yttrium-90-labeled anti-CEA MAb T84.66 --
XTL 001 -- XTL Biopharmaceuticals	ZD 0490 -- AstraZeneca
XTL 002 -- XTL Biopharmaceuticals	ziconotide -- Elan
yeast delivery system -- GlobelImmune	ZK 157138 -- Berlex Laboratories
Yersinia pestis vaccine	Zolimomab aritox
YIGSR-Stealth -- Johnson & Johnson	Zorcell -- Immune Response
Yisum Project No. D-0460 -- Yisum	ZRXL peptides -- Novartis



Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
At1g08280	<i>Arabidopsis thaliana</i>	n.d.	AC011438 BT004583 NC_003070	AAF18241.1 AAO42829.1 NP_172305.1	Q84W00 Q9SGD2	
At1g08660/F22O13.14	<i>Arabidopsis thaliana</i>	n.d.	AC003981 AY064135 AY124807 NC_003070 NM_180609	AAF99778.1 AAL36042.1 AAM70516.1 NP_172342.1 NP_850940.1	Q8VZJ0 Q9FRR9	
At3g48820/T21J18_90	<i>Arabidopsis thaliana</i>	n.d.	AY080589 AY133816 AL132963 NM_114741	AAL85966.1 AAM91750.1 CAB87910.1 NP_190451.1	Q8RY00 Q9M301	
$\alpha$ -2,3-sialyltransferase (ST3Gal-IV)	<i>Bos taurus</i>	n.d.	AJ584673	CAE48298.1		
$\alpha$ -2,3-sialyltransferase (St3Gal-V)	<i>Bos taurus</i>	n.d.	AJ585768	CAE51392.1		
$\alpha$ -2,6-sialyltransferase (Siat7b)	<i>Bos taurus</i>	n.d.	AJ620651	CAF05850.1		
$\alpha$ -2,8-sialyltransferase (SIAT8A)	<i>Bos taurus</i>	2.4.99.8	AJ699418	CAG27880.1		
$\alpha$ -2,8-sialyltransferase (Siat8D)	<i>Bos taurus</i>	n.d.	AJ699421	CAG27883.1		
$\alpha$ -2,8-sialyltransferase ST8Sia $\alpha$ -III (Siat8C)	<i>Bos taurus</i>	n.d.	AJ704563	CAG28696.1		
CMP $\alpha$ -2,6-sialyltransferase (ST6Gal I)	<i>Bos taurus</i>	2.4.99.1	Y15111 NM_177517	CAA75385.1 NP_803483.1	O18974	
sialyltransferase 8 (fragment)	<i>Bos taurus</i>	n.d.	AF450088	AAL47018.1	Q8WN13	
sialyltransferase ST3Gal-II (Siat4B)	<i>Bos taurus</i>	n.d.	AJ748841	CAG44450.1		
sialyltransferase ST3Gal-III (Siat6)	<i>Bos taurus</i>	n.d.	AJ748842	CAG44451.1		
sialyltransferase ST3Gal-VI (Siat10)	<i>Bos taurus</i>	n.d.	AJ748843	CAG44452.1		
ST3Gal I	<i>Bos taurus</i>	n.d.	AJ305086	CAC24698.1	Q9BEG4	
St6GalNAc-VI	<i>Bos taurus</i>	n.d.	AJ620949	CAF06586.1		
CDS4	<i>Branchiostoma floridae</i>	n.d.	AF391289	AAM18873.1	Q8T771	
polysialyltransferase (PST) (fragment) ST8Sia IV	<i>Cercopithecus aethiops</i>	2.4.99.-	AF210729	AAF17105.1	Q9TT09	
polysialyltransferase (STX) (fragment) ST8Sia II	<i>Cercopithecus aethiops</i>	2.4.99.-	AF210318	AAF17104.1	Q9TT10	
$\alpha$ -2,3-sialyltransferase ST3Gal I (Siat4)	<i>Ciona intestinalis</i>	n.d.	AJ626815	CAF25173.1		
$\alpha$ -2,3-sialyltransferase ST3Gal I (Siat4)	<i>Ciona savignyi</i>	n.d.	AJ626814	CAF25172.1		
$\alpha$ -2,8-polysialyltransferase ST8Sia IV	<i>Cricetulus griseus</i>	2.4.99.-	- Z46801	AAE28634 CAA86822.1	Q64690	
Gal $\beta$ -1,3/4-GlcNAc $\alpha$ -2,3-sialyltransferase ST3Gal I	<i>Cricetulus griseus</i>	n.d.	AY266675	AAP22942.1	Q80WL0	
Gal $\beta$ -1,3/4-GlcNAc $\alpha$ -2,3-sialyltransferase ST3Gal II (fragment)	<i>Cricetulus griseus</i>	n.d.	AY266676	AAP22943.1	Q80WK9	
$\alpha$ -2,3-sialyltransferase ST3Gal I (Siat4)	<i>Danio rerio</i>	n.d.	AJ783740	CAH04017.1		
$\alpha$ -2,3-sialyltransferase ST3Gal II (Siat5)	<i>Danio rerio</i>	n.d.	AJ783741	CAH04018.1		

FIG. 2A

Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
$\alpha$ -2,3-sialyltransferase ST3Gal III (Siat6)	<i>Danio rerio</i>	n.d.	AJ626821	CAF25179.1		
$\alpha$ -2,3-sialyltransferase ST3Gal IV (Siat4c)	<i>Danio rerio</i>	n.d.	AJ744809	CAG32845.1		
$\alpha$ -2,3-sialyltransferase ST3Gal V-r (Siat5-related)	<i>Danio rerio</i>	n.d.	AJ783742	CAH04019.1		
$\alpha$ -2,6-sialyltransferase ST6Gal I (Siat1)	<i>Danio rerio</i>	n.d.	AJ744801	CAG32837.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc II (Siat7B)	<i>Danio rerio</i>	n.d.	AJ634459	CAG25680.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc V (Siat7E) (fragment)	<i>Danio rerio</i>	n.d.	AJ646874	CAG26703.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc VI (Siat7F) (fragment)	<i>Danio rerio</i>	n.d.	AJ646883	CAG26712.1		
$\alpha$ -2,8-sialyltransferase ST8Sia I (Siat 8A) (fragment)	<i>Danio rerio</i>	n.d.	AJ715535	CAG29374.1		
$\alpha$ -2,8-sialyltransferase ST8Sia III (Siat 8C) (fragment)	<i>Danio rerio</i>	n.d.	AJ715543	CAG29382.1		
$\alpha$ -2,8-sialyltransferase ST8Sia IV (Siat 8D) (fragment)	<i>Danio rerio</i>	n.d.	AJ715545	CAG29384.1		
$\alpha$ -2,8-sialyltransferase ST8Sia V (Siat 8E) (fragment)	<i>Danio rerio</i>	n.d.	AJ715546	CAG29385.1		
$\alpha$ -2,8-sialyltransferase ST8Sia VI (Siat 8F) (fragment)	<i>Danio rerio</i>	n.d.	AJ715551	CAG29390.1		
$\beta$ -galactosamide $\alpha$ -2,6-sialyltransferase II (ST6Gal II)	<i>Danio rerio</i>	n.d.	AJ627627	CAF29495.1		
N-glycan $\alpha$ -2,8-sialyltransferase	<i>Danio rerio</i>	n.d.	BC050483 AY055462 NM_153662	AAH50483.1 AAL17875.1 NP_705948.1	Q7ZU51 Q8QH83	
ST3Gal III-related (sial6r)	<i>Danio rerio</i>	n.d.	BC053179 AJ626820 NM_200355	AAH53179.1 CAF25178.1 NP_956649.1	Q7T3B9	
St3Gal-V	<i>Danio rerio</i>	n.d.	AJ619960	CAF04061.1		
st6GalNAc-VI	<i>Danio rerio</i>	n.d.	BC060932 AJ620947	AAH60932.1 CAF06584.1		
$\alpha$ -2,6-sialyltransferase (CG4871) ST6Gal I	<i>Drosophila melanogaster</i>	2.4.99.1	AE003465 AF218237 AF397532 AE003465 NM_079129 NM_166684	AAF47256.1 AAG13185.1 AAK92126.1 AAM70791.1 NP_523853.1 NP_726474.1	Q9GU23 Q9W121	
$\alpha$ -2,3-sialyltransferase (ST3Gal-VI)	<i>Gallus gallus</i>	n.d.	AJ585767 AJ627204	CAE51391.1 CAF25503.1		
$\alpha$ -2,3-sialyltransferase ST3Gal I	<i>Gallus gallus</i>	2.4.99.4	X80503 NM_205217	CAA56666.1 NP_990548.1	Q11200	
$\alpha$ -2,3-sialyltransferase ST3Gal IV (fragment)	<i>Gallus gallus</i>	2.4.99.-	AF035250	AAC14163.1	O73724	
$\alpha$ -2,3-sialyltransferase (ST3GAL-II)	<i>Gallus gallus</i>	n.d.	AJ585761	CAE51385.2		
$\alpha$ -2,6-sialyltransferase (Siat7b)	<i>Gallus gallus</i>	n.d.	AJ620653	CAF05852.1		
$\alpha$ -2,6-sialyltransferase ST6Gal I	<i>Gallus gallus</i>	2.4.99.1	X75558 NM_205241	CAA53235.1 NP_990572.1	Q92182	
$\alpha$ -2,6-sialyltransferase	<i>Gallus gallus</i>	2.4.99.3	-	AAE68028.1	Q92183	

FIG. 2B

Protein	Organism	EC#	GenBank / GenPept	SwissProt	PDB / 3D
ST6GalNAc I			-	AAE68029.1 CAA52902.1 NP_990571.1	
$\alpha$ -2,6-sialyltransferase ST6GalNAc II	<i>Gallus gallus</i>	2.4.99.-	X74946 NM_205240 X77775 NM_205233	AAE68030.1 CAA54813.1 NP_990564.1	Q92184
$\alpha$ -2,6-sialyltransferase ST6GalNAc III (SIAT7C) (fragment)	<i>Gallus gallus</i>	n.d.	AJ634455	CAG25677.1	
$\alpha$ -2,6-sialyltransferase ST6GalNAc V (SIAT7E) (fragment)	<i>Gallus gallus</i>	n.d.	AJ646877	CAG26706.1	
$\alpha$ -2,8-sialyltransferase (GD3 Synthase) ST8Sia I	<i>Gallus gallus</i>	2.4.99.-	U73176	AAC28888.1	P79783
$\alpha$ -2,8-sialyltransferase (SIAT8B)	<i>Gallus gallus</i>	n.d.	AJ699419	CAG27881.1	
$\alpha$ -2,8-sialyltransferase (SIAT8C)	<i>Gallus gallus</i>	n.d.	AJ699420	CAG27882.1	
$\alpha$ -2,8-sialyltransferase (SIAT8F)	<i>Gallus gallus</i>	n.d.	AJ699424	CAG27886.1	
$\alpha$ -2,8-sialyltransferase ST8Sia-V (SIAT8C)	<i>Gallus gallus</i>	n.d.	AJ704564	CAG28697.1	
$\beta$ -galactosamide $\alpha$ -2,6- sialyltransferase II (ST6Gal II)	<i>Gallus gallus</i>	n.d.	AJ627629	CAF29497.1	
GM3 synthase (SIAT9)	<i>Gallus gallus</i>	2.4.99.9	AY515255	AAS83519.1	
polysialyltransferase ST8Sia IV	<i>Gallus gallus</i>	2.4.99.-	AF008194	AAB95120.1	O42399
$\alpha$ -2,3-sialyltransferase ST3Gal I	<i>Homo sapiens</i>	2.4.99.4	L29555 AF059321 L13972 AF155238 AF186191 BC018357 NM_003033 NM_173344	AAA36612.1 AAC17874.1 AAC37574.1 AAD39238.1 AAG29876.1 AAH18357.1 NP_003024.1 NP_775479.1	Q11201 O60677 Q9UN51
$\alpha$ -2,3-sialyltransferase ST3Gal II	<i>Homo sapiens</i>	2.4.99.4	U63090 BC036777 X96667 NM_006927	AAB40389.1 AAH36777.1 CAA65447.1 NP_008858.1	Q16842 O00654
$\alpha$ -2,3-sialyltransferase ST3Gal III (SiaT6)	<i>Homo sapiens</i>	2.4.99.6	L23768 BC050380 AF425851 AF425852 AF425853 AF425854 AF425855 AF425856 AF425857 AF425858 AF425859 AF425860 AF425861 AF425862 AF425863 AF425864 AF425865 AF425866 AF425867 AY167992 AY167993 AY167994	AAA35778.1 AAH50380.1 AAO13859.1 AAO13860.1 AAO13861.1 AAO13862.1 AAO13863.1 AAO13864.1 AAO13865.1 AAO13866.1 AAO13867.1 AAO13868.1 AAO13869.1 AAO13870.1 AAO13871.1 AAO13872.1 AAO13873.1 AAO13874.1 AAO13875.1 AAO38806.1 AAO38807.1 AAO38808.1	Q11203 Q86UR6 Q86UR7 Q86UR8 Q86UR9 Q86US0 Q86US1 Q86US2 Q8IX43 Q8IX44 Q8IX45 Q8IX46 Q8IX47 Q8IX48 Q8IX49 Q8IX50 Q8IX51 Q8IX52 Q8IX53 Q8IX54 Q8IX55 Q8IX56

FIG. 2C

Protein	Organism	EC#	GenBank / GenPept	SwissProt	PDB / 3D
			AY167995 AAO38809.1 AY167996 AAO38810.1 AY167997 AAO38811.1 AY167998 AAO38812.1 NM_006279 NP_006270.1 NM_174964 NP_777624.1 NM_174965 NP_777625.1 NM_174966 NP_777626.1 NM_174967 NP_777627.1 NM_174969 NP_777629.1 NM_174970 NP_777630.1 NM_174972 NP_777632.1	Q8IX57 Q8IX58	
$\alpha$ -2,3-sialyltransferase ST3Gal IV	<i>Homo sapiens</i>	2.4.99.-	L23767 AAA16460.1 AF035249 AAC14162.1 BC010645 <b>AAH10645.1</b> AY040826 AAK93790.1 AF516602 AAM66431.1 AF516603 AAM66432.1 AF516604 AAM66433.1 AF525084 AAM81378.1 X74570 CAA52662.1 CR456858 CAG33139.1 NM_006278 NP_006269.1	Q11206 O60497 Q96QQ9 Q8N6A6 Q8N6A7 Q8NFD3 Q8NFG7	
$\alpha$ -2,3-sialyltransferase ST3Gal VI	<i>Homo sapiens</i>	2.4.99.4	AF119391 <b>AAD39131.1</b> BC023312 AAH23312.1 AB022918 BAA77609.1 AX877828 CAE89895.1 AX886023 CAF00161.1 NM_006100 NP_006091.1	Q9Y274	
$\alpha$ -2,6-sialyltransferase (ST6Gal II ; KIAA1877)	<i>Homo sapiens</i>	n.d.	BC008680 AAH08680.1 AB058780 <b>BAB47506.1</b> AB059555 BAC24793.1 AJ512141 CAD54408.1 AX795193 CAE48260.1 AX795193 CAE48261.1 NM_032528 NP_115917.1	Q86Y44 Q8IUG7 Q96HE4 Q96JF0	
$\alpha$ -2,6-sialyltransferase (ST6GALNAC III)	<i>Homo sapiens</i>	n.d.	BC059363 AAH59363.1 AY358540 AAQ88904.1 AK091215 BAC03611.1 AJ507291 <b>CAD45371.1</b> NM_152996 NP_694541.1	Q8N259 Q8NDV1	
$\alpha$ -2,6-sialyltransferase (ST6GalNAc V)	<i>Homo sapiens</i>	n.d.	BC001201 <b>AAH01201.1</b> AK056241 BAB71127.1 AL035409 CAB72344.1 AJ507292 CAD45372.1 NM_030965 NP_112227.1	Q9BVH7	
$\alpha$ -2,6-sialyltransferase (SThM) ST6GalNAc II	<i>Homo sapiens</i>	2.4.99.-	U14550 AAA52228.1 BC040455 <b>AAH40455.1</b> AJ251053 CAB61434.1 NM_006456 NP_006447.1	Q9UJ37 Q12971	
$\alpha$ -2,6-sialyltransferase ST6Gal I	<i>Homo sapiens</i>	2.4.99.1	BC031476 AAH31476.1 BC040009 AAH40009.1 A17362 <b>CAA01327.1</b> A23699 CAA01686.1 X17247 CAA35111.1 X54363 CAA38246.1 X62822 CAA44634.1 NM_003032 NP_003023.1 NM_173216 NP_775323.1	P15907	
$\alpha$ -2,6-sialyltransferase ST6GalNAc I	<i>Homo sapiens</i>	2.4.99.3	BC022462 AAH22462.1 AY096001 AAM22800.1 AY358918 AAQ89277.1 AK000113 BAA90953.1 Y11339 <b>CAA72179.2</b>	Q8TBJ6 Q9NSC7 Q9NXQ7	

FIG. 2D

Protein	Organism	EC#	GenBank / GenPept	SwissProt	PDB / 3D
$\alpha$ -2,8-polysialyltransferase ST8Sia IV	<i>Homo sapiens</i>	2.4.99.-	NM_018414 L41680 BC027866 BC053657 NM_005668 NP_060884.1 AAC41775.1 AAH27866.1 <b>AAH53657.1</b> NP_005659.1	Q8N1F4 Q92187 Q92693	
$\alpha$ -2,8-sialyltransferase (GD3 synthase) ST8Sia I	<i>Homo sapiens</i>	2.4.99.8	L32867 L43494 BC046158 - AY569975 D26360 X77922 NM_003034 L32867 L43494 BC046158 - AY569975 D26360 X77922 NM_003034 NP_003025.1 AAA62366.1 <b>AAC37586.1</b> AAH46158.1 AAQ53140.1 AAS75783.1 BAA05391.1 CAA54891.1	Q86X71 Q92185 Q93064	
$\alpha$ -2,8-sialyltransferase ST8Sia II	<i>Homo sapiens</i>	2.4.99.-	L29556 U82762 U33551 BC069584 NM_006011 L29556 U82762 U33551 BC069584 NM_006011 NP_006002.1 AAA36613.1 AAB51242.1 <b>AAC24458.1</b> AAH69584.1	Q92186 Q92470 Q92746	
$\alpha$ -2,8-sialyltransferase ST8Sia III	<i>Homo sapiens</i>	2.4.99.-	AF004668 AF003092 NM_015879 AF004668 AF003092 NM_015879 NP_056963.1 <b>AAB87642.1</b> AAC15901.2	O43173 Q9NS41	
$\alpha$ -2,8-sialyltransferase ST8Sia V	<i>Homo sapiens</i>	2.4.99.-	U91641 CR457037 NM_013305 U91641 CR457037 NM_013305 NP_037437.1 <b>AAC51727.1</b> CAG33318.1	O15466	
ENSP00000020221 (fragment)		n.d.	AC023295		
lactosylceramide $\alpha$ -2,3-sialyltransferase (ST3Gal V)	<i>Homo sapiens</i>	2.4.99.9	AF105026 AF119415 BC065936 AY152815 AAP65066 AY359105 AB018356 AX876536 NM_003896 AF105026 AF119415 BC065936 AY152815 AAP65066 AY359105 AB018356 AX876536 NM_003896 NP_003887.2 AAD14634.1 AAF66146.1 AAH65936.1 AAO16866.1 AAP65066.1 AAQ89463.1 BAA33950.1 CAE89320.1	Q9UNP4 O94902	
N-acetylgalactosaminide $\alpha$ -2,6-sialyltransferase (ST6GalNAc VI)	<i>Homo sapiens</i>	2.4.99.-	BC006564 BC007802 BC016299 AY358672 AB035173 AK023900 AJ507293 AX880950 CR457318 NM_013443 BC006564 BC007802 BC016299 AY358672 AB035173 AK023900 AJ507293 AX880950 CR457318 NM_013443 NP_038471.2 AAH06564.1 AAH07802.1 AAH16299.1 AAQ89035.1 <b>BAA87035.1</b> BAB14715.1 CAD45373.1 CAE91145.1 CAG33599.1	Q969X2 Q9H8A2 Q9ULB8	
N-acetylgalactosaminide $\alpha$ -2,6-sialyltransferase IV (ST6GalNAc IV)	<i>Homo sapiens</i>	2.4.99.-	AF127142 BC036705 - AB035172 AK000600 Y17461 AJ271734 AX061620 AX068265 AX969252 NM_014403 NM_175039 AF127142 BC036705 - AB035172 AK000600 Y17461 AJ271734 AX061620 AX068265 AX969252 NM_014403 NM_175039 NP_055218.3 NP_778204.1 AAF00102.1 AAH36705.1 AAP63349.1 <b>BAA87034.1</b> BAA91281.1 CAB44354.1 CAC07404.1 CAC24981.1 CAC27250.1 CAF14360.1	Q9H4F1 Q9NWU6 Q9UKU1 Q9ULB9 Q9Y3G3 Q9Y3G4	
ST8SIA-VI (fragment)	<i>Homo sapiens</i>	n.d.	AJ621583 XM_291725 AJ621583 XM_291725 XP_291725.2 <b>CAF21722.1</b>		
unnamed protein product	<i>Homo sapiens</i>	n.d.	AK021929 AX881696 AK021929 AX881696 NP_055218.3 <b>BAB13940.1</b> CAE91353.1	Q9HAA9	
Gal $\beta$ -1,3/4-GlcNAc $\alpha$ -	<i>Mesocricetus</i>	2.4.99.6	AJ245699 AJ245699 NP_055218.3 <b>CAB53394.1</b>	Q9QXF6	

FIG. 2E

Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
2,3-sialyltransferase (ST3Gal III)	<i>auratus</i>					
Gal $\beta$ -1,3/4-GlcNAc $\alpha$ -2,3-sialyltransferase (ST3Gal IV)	<i>Mesocricetus auratus</i>	2.4.99.6	AJ245700	<b>CAB53395.1</b>	Q9QXF5	
GD3 synthase (fragment) ST8Sia I	<i>Mesocricetus auratus</i>	n.d.	AF141657	<b>AAD33879.1</b>	Q9WUL1	
polysialyltransferase (ST8Sia IV)	<i>Mesocricetus auratus</i>	2.4.99.-	AJ245701	<b>CAB53396.1</b>	Q9QXF4	
$\alpha$ -2,3-sialyltransferase ST3Gal I	<i>St3gal1</i> <i>Mus musculus</i>	2.4.99.4	AF214028 AK031344 AK078469 X73523 NM_009177	AAF60973.1 BAC27356.1 BAC37290.1 CAA51919.1 NP_033203.1	<b>P54751</b> <b>Q11202</b> Q9JL30	
$\alpha$ -2,3-sialyltransferase ST3Gal II	<i>St3gal2</i> <i>Mus musculus</i>	2.4.99.4	BC015264 BC066064 AK034554 AK034863 AK053827 X76989 NM_009179 NM_178048	<b>AAH15264.1</b> AAH66064.1 BAC28752.1 BAC28859.1 BAC35543.1 CAA54294.1 NP_033205.1 NP_835149.1	Q11204 Q8BPL0 Q8BSA0 Q8BSE9 Q91WH6	
$\alpha$ -2,3-sialyltransferase ST3Gal III	<i>St3gal3</i> <i>Mus musculus</i>	2.4.99.-	BC006710 AK005053 AK013016 X84234 NM_009176	AAH06710.1 <b>BAB23779.1</b> BAB28598.1 CAA59013.1 NP_033202.2	P97325 Q922X5 Q9CZ48 Q9DBB6	
$\alpha$ -2,3-sialyltransferase ST3Gal IV	<i>St3gal4</i> <i>Mus musculus</i>	2.4.99.4	BC011121 BC050773 D28941 AK008543 AB061305 X95809 NM_009178	AAH11121.1 <b>AAH50773.1</b> BAA06068.1 BAB25732.1 BAB47508.1 CAA65076.1 NP_033204.2	P97354 Q61325 Q91Y74 Q921R5 Q9CVE8	
$\alpha$ -2,3-sialyltransferase ST3Gal VI	<i>St3gal6</i> <i>Mus musculus</i>	2.4.99.4	AF119390 BC052338 AB063326 AK033562 AK041173 NM_018784	AAD39130.1 AAH52338.1 <b>BAB79494.1</b> BAC28360.1 BAC30851.1 NP_061254	Q80UR7 Q8BLV1 Q8VIB3 Q9WVG2	
$\alpha$ -2,6-sialyltransferase ST6GalNAc II	<i>St6galnac2</i> <i>Mus musculus</i>	2.4.99.-	NM_009180 BC010208 AB027198 AK004613 X93999 X94000 NM_009180	6677963 AAH10208.1 BAB00637.1 BAB23410.1 CAA63821.1 CAA63822.1 NP_033206.2	<b>P70277</b> Q9DC24 Q9JIM5	
$\alpha$ -2,6-sialyltransferase ST6Gal I	<i>St6gal1</i> <i>Mus musculus</i>	2.4.99.1	- BC027833 D16106 AK034768 AK084124 NM_145933	AAE68031.1 AAH27833.1 BAA03680.1 BAC28828.1 BAC39120.1 NP_666045.1	<b>Q64685</b> Q8BM62 Q8K1L1	
$\alpha$ -2,6-sialyltransferase ST6Gal II	<i>St6gal2</i> <i>Mus musculus</i>	n.d.	AK082566 AB095093 AK129462 NM_172829	BAC38534.1 <b>BAC87752.1</b> BAC98272.1 NP_766417.1	Q8BUU4	
$\alpha$ -2,6-sialyltransferase ST6GalNAc I	<i>St6galnac1</i> <i>Mus musculus</i>	2.4.99.3	Y11274 NM_011371	<b>CAA72137.1</b> NP_035501.1	Q9QZ39 Q9JJP5	
$\alpha$ -2,6-sialyltransferase ST6GalNAc III	<i>St6galnac3</i> <i>Mus musculus</i>	n.d.	BC058387 AK034804 Y11342 Y11343	AAH58387.1 BAC28836.1 CAA72181.2 <b>CAB95031.1</b>	Q9WUV2 Q9JHP5	

FIG. 2F

Protein	Organism		EC#	GenBank / GenPept		SwissProt	PDB / 3D
$\alpha$ -2,6-sialyltransferase ST6GalNAc IV	<i>St6galnac4</i>	<i>Mus musculus</i>	2.4.99.7	NM_011372 BC056451 AK085730 AJ007310 Y15779 Y15780 Y19055 Y19057 NM_011373	NP_035502 AAH56451.1 BAC39523.1 CAA07446.1 CAB43507.1 <b>CAB43514.1</b> CAB93946.1 CAB93948.1 NP_035503.1	Q8C3J2 Q9JHP2 Q9R2B6 O88725 Q9JHP0 Q9QUP9 Q9R2B5	
$\alpha$ -2,8-sialyltransferase (GD3 synthase) ST8Sia I	<i>St8sia1</i>	<i>Mus musculus</i>	2.4.99.8	L38677 BC024821 AK046188 AK052444 X84235 AJ401102 NM_011374	AAA91869.1 <b>AAH24821.1</b> BAC32625.1 BAC34994.1 CAA59014.1 CAC20706.1 NP_035504.1	Q64468 Q64687 Q8BL76 Q8BWI0 Q8K1C1 Q9EPK0	
$\alpha$ -2,8-sialyltransferase (ST8Sia VI)	<i>St8sia6</i>	<i>Mus musculus</i>	n.d.	AB059554 AK085105 NM_145838	<b>BAC01265.1</b> BAC39367.1 NP_665837.1	Q8BI43 Q8K4T1	
$\alpha$ -2,8-sialyltransferase ST8Sia II	<i>St8sia2</i>	<i>Mus musculus</i>	2.4.99.-	X83562 X99646 X99647 X99648 X99649 X99650 X99651 NM_009181	CAA58548.1 CAA67965.1 CAA67965.1 CAA67965.1 CAA67965.1 CAA67965.1 CAA67965.1 NP_033207.1	<b>O35696</b>	
$\alpha$ -2,8-sialyltransferase ST8Sia IV	<i>St8sia4</i>	<i>Mus musculus</i>	2.4.99.8	BC060112 AK003690 AK041723 AJ223956 X86000 Y09484 NM_009183	AAH60112.1 BAB22941.1 BAC31044.1 <b>CAA11685.1</b> CAA59992.1 CAA70692.1 NP_033209.1	Q64692 Q8BY70	
$\alpha$ -2,8-sialyltransferase ST8Sia V	<i>St8sia5</i>	<i>Mus musculus</i>	2.4.99.-	BC034855 AK078670 X98014 X98014 X98014 NM_013666 NM_153124 NM_177416	AAH34855.1 BAC37354.1 <b>CAA66642.1</b> CAA66643.1 CAA66644.1 NP_038694.1 NP_694764.1 NP_803135.1	P70126 P70127 P70128 Q8BJW0 Q8JZQ3	
$\alpha$ -2,8-sialyltransferase ST8Sia III	<i>St8sia3</i>	<i>Mus musculus</i>	2.4.99.-	BC075645 AK015874 X80502 NM_009182	AAH75645.1 BAB30012.1 CAA56665.1 NP_033208.1	<b>Q64689</b> Q9CUJ6	
GD1 synthase (ST6GalNAc V)	<i>St6galnac5</i>	<i>Mus musculus</i>	n.d.	BC055737 AB030836 AB028840 AK034387 AK038434 AK042683 NM_012028	<b>AAH55737.1</b> BAA85747.1 BAA89292.1 BAC28693.1 BAC29997.1 BAC31331.1 NP_036158.2	Q8CAM7 Q8CBX1 Q9QYJ1 Q9R0K6	
GM3 synthase ( $\alpha$ -2,3- sialyltransferase) ST3Gal V	<i>St3gal5</i>	<i>Mus musculus</i>	2.4.99.9	AF119416 - AB018048 AB013302 AK012961 Y15003 NM_011375	<b>AAF66147.1</b> AAP65063.1 BAA33491.1 BAA76467.1 BAB28571.1 CAA75235.1 NP_035505.1	Q88829 Q9CZ65 Q9QWF9	
N- acetylgalactosaminide $\alpha$ -2,6-sialyltransferase (ST6GalNAc VI)	<i>St6galnac6</i>	<i>Mus musculus</i>	2.4.99.-	BC036985 AB035174 AB035123 AK030648	<b>AAH36985.1</b> BAA87036.1 BAA95940.1 BAC27064.1	Q8CDC3 Q8JZW3 Q9JMG5 Q9R0G9	

FIG. 2G

Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
M138L	<i>Myxoma virus</i>	n.d.	NM_016973 U46578 AF170726 NC_001132	NP_058669.1 AAD00069.1 AAE61323.1 AAE61326.1 <b>AAF15026.1</b> NP_051852.1		
$\alpha$ -2,3-sialyltransferase (St3Gal-I)	<i>Oncorhynchus mykiss</i>	n.d.	AJ585760	<b>CAE51384.1</b>		
$\alpha$ -2,6-sialyltransferase (Siat1)	<i>Oncorhynchus mykiss</i>	n.d.	AJ620649	<b>CAF05848.1</b>		
$\alpha$ -2,8-polysialyltransferase IV (ST8Sia IV)	<i>Oncorhynchus mykiss</i>	n.d.	AB094402	<b>BAC77411.1</b>	Q7T2X5	
GalNAc $\alpha$ -2,6-sialyltransferase (RtST6GalNAc)	<i>Oncorhynchus mykiss</i>	n.d.	AB097943	<b>BAC77520.1</b>	Q7T2X4	
$\alpha$ -2,3-sialyltransferase ST3Gal IV	<i>Oryctolagus cuniculus</i>	2.4.99.-	AF121967	<b>AAF28871.1</b>	Q9N257	
OJ1217_F02.7	<i>Oryza sativa (japonica cultivar-group)</i>	n.d.	AP004084	<b>BAD07616.1</b>		
OSJNBa0043L24.2 or OSJNBb0002J11.9	<i>Oryza sativa (japonica cultivar-group)</i>	n.d.	AL731626 AL662969	<b>CAD41185.1</b> CAE04714.1		
P0683f02.18 or P0489B03.1	<i>Oryza sativa (japonica cultivar-group)</i>	n.d.	AP003289 AP003794	<b>BAB63715.1</b> BAB90552.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc V (Siat7E) (fragment)	<i>Oryzias latipes</i>	n.d.	AJ646876	<b>CAG26705.1</b>		
$\alpha$ -2,3-sialyltransferase ST3Gal I (Siat4)	<i>Pan troglodytes</i>	n.d.	AJ744803	<b>CAG32839.1</b>		
$\alpha$ -2,3-sialyltransferase ST3Gal II (Siat5)	<i>Pan troglodytes</i>	n.d.	AJ744804	<b>CAG32840.1</b>		
$\alpha$ -2,3-sialyltransferase ST3Gal III (Siat6)	<i>Pan troglodytes</i>	n.d.	AJ626819	<b>CAF25177.1</b>		
$\alpha$ -2,3-sialyltransferase ST3Gal IV (Siat4c)	<i>Pan troglodytes</i>	n.d.	AJ626824	<b>CAF25182.1</b>		
$\alpha$ -2,3-sialyltransferase ST3Gal VI (Siat10)	<i>Pan troglodytes</i>	n.d.	AJ744808	<b>CAG32844.1</b>		
$\alpha$ -2,6-sialyltransferase (Sia7A)	<i>Pan troglodytes</i>	n.d.	AJ748740	<b>CAG38615.1</b>		
$\alpha$ -2,6-sialyltransferase (Sia7B)	<i>Pan troglodytes</i>	n.d.	AJ748741	<b>CAG38616.1</b>		
$\alpha$ -2,6-sialyltransferase ST6GalNAc III (Siat7C)	<i>Pan troglodytes</i>	n.d.	AJ634454	<b>CAG25676.1</b>		
$\alpha$ -2,6-sialyltransferase ST6GalNAc IV (Siat7D) (fragment)	<i>Pan troglodytes</i>	n.d.	AJ646870	<b>CAG26699.1</b>		
$\alpha$ -2,6-sialyltransferase ST6GalNAc V (Siat7E)	<i>Pan troglodytes</i>	n.d.	AJ646875	<b>CAG26704.1</b>		
$\alpha$ -2,6-sialyltransferase ST6GalNAc VI (Siat7F) (fragment)	<i>Pan troglodytes</i>	n.d.	AJ646882	<b>CAG26711.1</b>		
$\alpha$ -2,8-sialyltransferase 8A (Siat8A)	<i>Pan troglodytes</i>	2.4.99.8	AJ697658	<b>CAG26896.1</b>		
$\alpha$ -2,8-sialyltransferase 8B (Siat8B)	<i>Pan troglodytes</i>	n.d.	AJ697659	<b>CAG26897.1</b>		
$\alpha$ -2,8-sialyltransferase 8C (Siat8C)	<i>Pan troglodytes</i>	n.d.	AJ697660	<b>CAG26898.1</b>		
$\alpha$ -2,8-sialyltransferase 8D (Siat8D)	<i>Pan troglodytes</i>	n.d.	AJ697661	<b>CAG26899.1</b>		
$\alpha$ -2,8-sialyltransferase	<i>Pan troglodytes</i>	n.d.	AJ697662	<b>CAG26900.1</b>		

FIG. 2H



Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
8E (Siat8E)						
$\alpha$ -2,8-sialyltransferase 8F (Siat8F)	<i>Pan troglodytes</i>	n.d.	AJ697663	CAG26901.1		
$\beta$ -galactosamide $\alpha$ -2,6-sialyltransferase I (ST6Gal I; Siat1)	<i>Pan troglodytes</i>	2.4.99.1	AJ627624	CAF29492.1		
$\beta$ -galactosamide $\alpha$ -2,6-sialyltransferase II (ST6Gal II)	<i>Pan troglodytes</i>	n.d.	AJ627625	CAF29493.1		
GM3 synthase ST3Gal V (Siat9)	<i>Pan troglodytes</i>	n.d.	AJ744807	CAG32843.1		
S138L	<i>Rabbit fibroma virus Kasza</i>	n.d.	NC_001266	NP_052025		
$\alpha$ -2,3-sialyltransferase ST3Gal III	<i>Rattus norvegicus</i>	2.4.99.6	M97754 NM_031697	AAA42146.1 NP_113885.1	Q02734	
$\alpha$ -2,3-sialyltransferase ST3Gal IV (Siat4c)	<i>Rattus norvegicus</i>	n.d.	AJ626825	CAF25183.1		
$\alpha$ -2,3-sialyltransferase ST3Gal VI	<i>Rattus norvegicus</i>	n.d.	AJ626743	CAF25053.1		
$\alpha$ -2,6-sialyltransferase ST3Gal II	<i>Rattus norvegicus</i>	2.4.99.-	X76988 NM_031695	CAA54293.1 NP_113883.1	Q11205	
$\alpha$ -2,6-sialyltransferase ST6Gal I	<i>Rattus norvegicus</i>	2.4.99.1	M18769 M83143	AAA41196.1 AAB07233.1	P13721	
$\alpha$ -2,6-sialyltransferase ST6GalNAc I (Siat7A)	<i>Rattus norvegicus</i>	n.d.	AJ634458	CAG25684.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc II (Siat7B)	<i>Rattus norvegicus</i>	n.d.	AJ634457	CAG25679.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc III	<i>Rattus norvegicus</i>	2.4.99.-	L29554 BC072501 NM_019123	AAC42086.1 AAH72501.1 NP_061996.1	Q64686	
$\alpha$ -2,6-sialyltransferase ST6GalNAc IV (Siat7D) (fragment)	<i>Rattus norvegicus</i>	n.d.	AJ646871	CAG26700.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc V (Siat7E)	<i>Rattus norvegicus</i>	n.d.	AJ646872	CAG26701.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc VI (Siat7F) (fragment)	<i>Rattus norvegicus</i>	n.d.	AJ646881	CAG26710.1		
$\alpha$ -2,8-sialyltransferase (GD3 synthase) ST8Sia I	<i>Rattus norvegicus</i>	2.4.99.-	U53883 D45255	AAC27541.1 BAA08213.1	P70554 P97713	
$\alpha$ -2,8-sialyltransferase (SIAT8E)	<i>Rattus norvegicus</i>	n.d.	AJ699422	CAG27884.1		
$\alpha$ -2,8-sialyltransferase (SIAT8F)	<i>Rattus norvegicus</i>	n.d.	AJ699423	CAG27885.1		
$\alpha$ -2,8-sialyltransferase ST8Sia II	<i>Rattus norvegicus</i>	2.4.99.-	L13445 NM_057156	AAA42147.1 NP_476497.1	Q07977 Q64688	
$\alpha$ -2,8-sialyltransferase ST8Sia III	<i>Rattus norvegicus</i>	2.4.99.-	U55938 NM_013029	AAB50061.1 NP_037161.1	P97877	
$\alpha$ -2,8-sialyltransferase ST8Sia IV	<i>Rattus norvegicus</i>	2.4.99.-	U90215	AAB49989.1	O08563	
$\beta$ -galactosamide $\alpha$ -2,6-sialyltransferase II (ST6Gal II)	<i>Rattus norvegicus</i>	n.d.	AJ627626	CAF29494.1		
GM3 synthase ST3Gal V	<i>Rattus norvegicus</i>	n.d.	AB018049 NM_031337	BAA33492.1 NP_112627.1	O88830	

FIG. 21

Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
sialyltransferase ST3Gal-I (Siat4A)	<i>Rattus norvegicus</i>	n.d.	AJ748840	CAG44449.1		
$\alpha$ -2,3-sialyltransferase (ST3Gal-II)	<i>Silurana tropicalis</i>	n.d.	AJ585763	CAE51387.1		
$\alpha$ -2,6-sialyltransferase (Siat7b)	<i>Silurana tropicalis</i>	n.d.	AJ620650	CAF05849.1		
$\alpha$ -2,6-sialyltransferase (ST6galnac)	<i>Strongylocentrotus purpuratus</i>	n.d.	AJ699425	CAG27887.1		
$\alpha$ -2,3-sialyltransferase (ST3GAL-III)	<i>Sus scrofa</i>	n.d.	AJ585765	CAE51389.1		
$\alpha$ -2,3-sialyltransferase (ST3GAL-IV)	<i>Sus scrofa</i>	n.d.	AJ584674	CAE48299.1		
$\alpha$ -2,3-sialyltransferase ST3Gal I	<i>Sus scrofa</i>	2.4.99.4	M97753	AAA31125.1	Q02745	
$\alpha$ -2,6-sialyltransferase (fragment) ST6Gal I	<i>Sus scrofa</i>	2.4.99.1	AF136746	AAD33059.1	Q9XSG8	
$\beta$ -galactosamide $\alpha$ -2,6-sialyltransferase (ST6GalNAc-V)	<i>Sus scrofa</i>	n.d.	AJ620948	CAF06585.2		
sialyltransferase (fragment) ST6Gal I	<i>sus scrofa</i>	n.d.	AF041031	AAC15633.1	O62717	
ST6GALNAc-V	<i>Sus scrofa</i>	n.d.	AJ620948	CAF06585.1		
$\alpha$ -2,3-sialyltransferase (Siat5-r)	<i>Takifugu rubripes</i>	n.d.	AJ744805	CAG32841.1		
$\alpha$ -2,3-sialyltransferase ST3Gal I (Siat4)	<i>Takifugu rubripes</i>	n.d.	AJ626816	CAF25174.1		
$\alpha$ -2,3-sialyltransferase ST3Gal II (Siat5) (fragment)	<i>Takifugu rubripes</i>	n.d.	AJ626817	CAF25175.1		
$\alpha$ -2,3-sialyltransferase ST3Gal III (Siat6)	<i>Takifugu rubripes</i>	n.d.	AJ626818	CAF25176.1		
$\alpha$ -2,6-sialyltransferase ST6Gal I (Siat1)	<i>Takifugu rubripes</i>	n.d.	AJ744800	CAG32836.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc II (Siat7B)	<i>Takifugu rubripes</i>	n.d.	AJ634460	CAG25681.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc II B (Siat7B-related)	<i>Takifugu rubripes</i>	n.d.	AJ634461	CAG25682.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc III (Siat7C) (fragment)	<i>Takifugu rubripes</i>	n.d.	AJ634456	CAG25678.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc IV (siat7D) (fragment)	<i>Takifugu rubripes</i>	2.4.99.3	Y17466 AJ646869	CAB44338.1 CAG26698.1	Q9W6U6	
$\alpha$ -2,6-sialyltransferase ST6GalNAc V (Siat7E) (fragment)	<i>Takifugu rubripes</i>	n.d.	AJ646873	CAG26702.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc VI (Siat7F) (fragment)	<i>Takifugu rubripes</i>	n.d.	AJ646880	CAG26709.1		
$\alpha$ -2,8-sialyltransferase ST8Sia I (Siat 8A) (fragment)	<i>Takifugu rubripes</i>	n.d.	AJ715534	CAG29373.1		
$\alpha$ -2,8-sialyltransferase ST8Sia II (Siat 8B) (fragment)	<i>Takifugu rubripes</i>	n.d.	AJ715538	CAG29377.1		
$\alpha$ -2,8-sialyltransferase ST8Sia III (Siat 8C) (fragment)	<i>Takifugu rubripes</i>	n.d.	AJ715541	CAG29380.1		
$\alpha$ -2,8-sialyltransferase ST8Sia IIIr (Siat 8Cr)	<i>Takifugu rubripes</i>	n.d.	AJ715542	CAG29381.1		
$\alpha$ -2,8-sialyltransferase ST8Sia V (Siat 8E)	<i>Takifugu rubripes</i>	n.d.	AJ715547	CAG29386.1		

FIG. 2J

Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
(fragment)						
$\alpha$ -2,8-sialyltransferase ST8Sia VI (Siat 8F) (fragment)	<i>Takifugu rubripes</i>	n.d.	AJ715549	CAG29388.1		
$\alpha$ -2,8-sialyltransferase ST8Sia VIr (Siat 8Fr)	<i>Takifugu rubripes</i>	n.d.	AJ715550	CAG29389.1		
$\alpha$ -2,3-sialyltransferase (Siat5-r)	<i>Tetraodon nigroviridis</i>	n.d.	AJ744806	CAG32842.1		
$\alpha$ -2,3-sialyltransferase ST3Gal I (Siat4)	<i>Tetraodon nigroviridis</i>	n.d.	AJ744802	CAG32838.1		
$\alpha$ -2,3-sialyltransferase ST3Gal III (Siat6)	<i>Tetraodon nigroviridis</i>	n.d.	AJ626822	CAF25180.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc II (Siat7B)	<i>Tetraodon nigroviridis</i>	n.d.	AJ634462	CAG25683.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc V (Siat7E) (fragment)	<i>Tetraodon nigroviridis</i>	n.d.	AJ646879	CAG26708.1		
$\alpha$ -2,8-sialyltransferase ST8Sia I (Siat 8A) (fragment)	<i>Tetraodon nigroviridis</i>	n.d.	AJ715536	CAG29375.1		
$\alpha$ -2,8-sialyltransferase ST8Sia II (Siat 8B) (fragment)	<i>Tetraodon nigroviridis</i>	n.d.	AJ715537	CAG29376.1		
$\alpha$ -2,8-sialyltransferase ST8Sia III (Siat 8C) (fragment)	<i>Tetraodon nigroviridis</i>	n.d.	AJ715539	CAG29378.1		
$\alpha$ -2,8-sialyltransferase ST8Sia IIIr (Siat 8Cr) (fragment)	<i>Tetraodon nigroviridis</i>	n.d.	AJ715540	CAG29379.1		
$\alpha$ -2,8-sialyltransferase ST8Sia V (Siat 8E) (fragment)	<i>Tetraodon nigroviridis</i>	n.d.	AJ715548	CAG29387.1		
$\alpha$ -2,3-sialyltransferase (St3Gal-II)	<i>Xenopus laevis</i>	n.d.	AJ585762	CAE51386.1		
$\alpha$ -2,3-sialyltransferase (St3Gal-VI)	<i>Xenopus laevis</i>	n.d.	AJ585766	CAE51390.1		
$\alpha$ -2,3-sialyltransferase St3Gal-III (Siat6)	<i>Xenopus laevis</i>	n.d.	AJ585764 AJ626823	CAE51388.1 CAF25181.1		
$\alpha$ -2,8- polysialyltransferase	<i>Xenopus laevis</i>	2.4.99.-	AB007468	BAA32617.1	O93234	
$\alpha$ -2,8-sialyltransferase ST8Sia-I (Siat8A;GD3 synthase)	<i>Xenopus laevis</i>	n.d.	AY272056 AY272057 AJ704562	AAQ16162.1 AAQ16163.1 CAG28695.1		
Unknown (protein for MGC:81265)	<i>Xenopus laevis</i>	n.d.	BC068760	AAH68760.1		
$\alpha$ -2,3-sialyltransferase (3Gal-VI)	<i>Xenopus tropicalis</i>	n.d.	AJ626744	CAF25054.1		
$\alpha$ -2,3-sialyltransferase (Siat4c)	<i>Xenopus tropicalis</i>	n.d.	AJ622908	CAF22058.1		
$\alpha$ -2,6-sialyltransferase ST6GalNAc V (Siat7E) (fragment)	<i>Xenopus tropicalis</i>	n.d.	AJ646878	CAG26707.1		
$\alpha$ -2,8-sialyltransferase ST8Sia III (Siat 8C) (fragment)	<i>Xenopus tropicalis</i>	n.d.	AJ715544	CAG29383.1		
$\beta$ -galactosamide $\alpha$ -2,6- sialyltransferase II (ST6Gal II)	<i>Xenopus tropicalis</i>	n.d.	AJ627628	CAF29496.1		
sialyltransferase St8SiaI	<i>Xenopus tropicalis</i>	n.d.	AY652775	AAT67042		
poly- $\alpha$ -2,8-sialosyl sialyltransferase (NeuS)	<i>Escherichia coli</i> K1	2.4.-.-	M76370 X60598	AAA24213.1 CAA43053.1	Q57269	
polysialyltransferase	<i>Escherichia coli</i> K92	2.4.-.-	M88479	AAA24215.1	Q47404	

FIG. 2K

Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
$\alpha$ -2,8 polysialyltransferase SiaD	<i>Neisseria meningitidis</i> B1940	2.4.-.-	M95053 X78068	AAA20478.1 CAA54985.1	Q51281 Q51145	
SynE	<i>Neisseria meningitidis</i> FAM18	n.d.	U75650	AAB53842.1	O06435	
polysialyltransferase (SiaD)(fragment)	<i>Neisseria meningitidis</i> M1019	n.d.	AY234192	AAO85290.1		
SiaD (fragment)	<i>Neisseria meningitidis</i> M209	n.d.	AY281046	AAP34769.1		
SiaD (fragment)	<i>Neisseria meningitidis</i> M3045	n.d.	AY281044	AAP34767.1		
polysialyltransferase (SiaD)(fragment)	<i>Neisseria meningitidis</i> M3315	n.d.	AY234191	AAO85289.1		
SiaD (fragment)	<i>Neisseria meningitidis</i> M3515	n.d.	AY281047	AAP34770.1		
polysialyltransferase (SiaD)(fragment)	<i>Neisseria meningitidis</i> M4211	n.d.	AY234190	AAO85288.1		
SiaD (fragment)	<i>Neisseria meningitidis</i> M4642	n.d.	AY281048	AAP34771.1		
polysialyltransferase (SiaD)(fragment)	<i>Neisseria meningitidis</i> M5177	n.d.	AY234193	AAO85291.1		
SiaD	<i>Neisseria meningitidis</i> M5178	n.d.	AY281043	AAP34766.1		
SiaD (fragment)	<i>Neisseria meningitidis</i> M980	n.d.	AY281045	AAP34768.1		
NMB0067	<i>Neisseria meningitidis</i> MC58	n.d.	NC_003112	NP_273131		
Lst	<i>Aeromonas punctata</i> Sch3	n.d.	AF126256	AAS66624.1		
ORF2	<i>Haemophilus influenzae</i> A2	n.d.	M94855	AAA24979.1		
HI1699	<i>Haemophilus influenzae</i> Rd	n.d.	U32842 NC_000907	AAC23345.1 NP_439841.1	Q48211	
$\alpha$ -2,3-sialyltransferase	<i>Neisseria gonorrhoeae</i> F62	2.4.99.4	U60664	AAC44539.1 AAE67205.1	P72074	
$\alpha$ -2,3-sialyltransferase	<i>Neisseria meningitidis</i> 126E, NRCC 4010	2.4.99.4	U60662	AAC44544.2		
$\alpha$ -2,3-sialyltransferase	<i>Neisseria meningitidis</i> 406Y, NRCC 4030	2.4.99.4	U60661	AAC44543.1		
$\alpha$ -2,3-sialyltransferase (NMB0922)	<i>Neisseria meningitidis</i> MC58	2.4.99.4	U60660 AE002443 NC_003112	AAC44541.1 AAF41330.1 NP_273962.1	P72097	
NMA1118	<i>Neisseria meningitidis</i> Z2491	n.d.	AL162755 NC_003116	CAB84380.1 NP_283887.1	Q9JUV5	
PM0508	<i>Pasteurella multocida</i> PM70	n.d.	AE006086 NC_002663	AAK02592.1 NP_245445.1	Q9CNC4	
WaaH	<i>Salmonella enterica</i> SARB25	n.d.	AF519787	AAM82550.1	Q8KS93	
WaaH	<i>Salmonella enterica</i> SARB3	n.d.	AF519788	AAM82551.1	Q8KS92	
WaaH	<i>Salmonella enterica</i> SARB39	n.d.	AF519789	AAM82552.1		
WaaH	<i>Salmonella enterica</i> SARB53	n.d.	AF519790	AAM82553.1		
WaaH	<i>Salmonella enterica</i> SARB57	n.d.	AF519791	AAM82554.1	Q8KS91	
WaaH	<i>Salmonella enterica</i> SARB71	n.d.	AF519793	AAM82556.1	Q8KS89	
WaaH	<i>Salmonella enterica</i>	n.d.	AF519792	AAM82555.1	Q8KS90	

FIG. 2L

Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
	SARB8					
WaaH	<i>Salmonella enterica</i> SARC10V	n.d.	AF519779	AAM88840.1	Q8KS99	
WaaH (fragment)	<i>Salmonella enterica</i> SARC12	n.d.	AF519781	AAM88842.1		
WaaH (fragment)	<i>Salmonella enterica</i> SARC13I	n.d.	AF519782	AAM88843.1	Q8KS98	
WaaH (fragment)	<i>Salmonella enterica</i> SARC14I	n.d.	AF519783	AAM88844.1	Q8KS97	
WaaH	<i>Salmonella enterica</i> SARC15II	n.d.	AF519784	AAM88845.1	Q8KS96	
WaaH	<i>Salmonella enterica</i> SARC16II	n.d.	AF519785	AAM88846.1	Q8KS95	
WaaH (fragment)	<i>Salmonella enterica</i> SARC3I	n.d.	AF519772	AAM88834.1	Q8KSA4	
WaaH (fragment)	<i>Salmonella enterica</i> SARC4I	n.d.	AF519773	AAM88835.1	Q8KSA3	
WaaH	<i>Salmonella enterica</i> SARC5IIa	n.d.	AF519774	AAM88836.1		
WaaH	<i>Salmonella enterica</i> SARC6IIa	n.d.	AF519775	AAM88837.1	Q8KSA2	
WaaH	<i>Salmonella enterica</i> SARC8	n.d.	AF519777	AAM88838.1	Q8KSA1	
WaaH	<i>Salmonella enterica</i> SARC9V	n.d.	AF519778	AAM88839.1	Q8KSA0	
UDP-glucose : $\alpha$ -1,2-glucosyltransferase (WaaH)	<i>Salmonella enterica</i> subsp. <i>arizonae</i> SARC 5	2.4.1.-	AF511116	AAM48166.1		
bifunctional $\alpha$ -2,3/-2,8-sialyltransferase (Cst-II)	<i>Campylobacter jejuni</i> ATCC 43449	n.d.	AF401529	AAL06004.1	Q93CZ5	
Cst	<i>Campylobacter jejuni</i> 81-176	n.d.	AF305571	AAL09368.1		
$\alpha$ -2,3-sialyltransferase (Cst-III)	<i>Campylobacter jejuni</i> ATCC 43429	2.4.99.-	AY044156	AAK73183.1		
$\alpha$ -2,3-sialyltransferase (Cst-III)	<i>Campylobacter jejuni</i> ATCC 43430	2.4.99.-	AF400047	AAK85419.1		
$\alpha$ -2,3-sialyltransferase (Cst-II)	<i>Campylobacter jejuni</i> ATCC 43432	2.4.99.-	AF215659	AAG43979.1	Q9F0M9	
$\alpha$ -2,3/8-sialyltransferase (CstII)	<i>Campylobacter jejuni</i> ATCC 43438	n.d.	AF400048	AAK91725.1	Q93MQ0	
$\alpha$ -2,3-sialyltransferase cst-II	<i>Campylobacter jejuni</i> ATCC 43446	2.4.99.-	AF167344	AAF34137.1		
$\alpha$ -2,3-sialyltransferase (Cst-II)	<i>Campylobacter jejuni</i> ATCC 43456	2.4.99.-	AF401528	AAL05990.1	Q93D05	
$\alpha$ -2,3/- $\alpha$ -2,8-sialyltransferase (CstII)	<i>Campylobacter jejuni</i> ATCC 43460	2.4.99.-	AY044868	AAK96001.1	Q938X6	
$\alpha$ -2,3/8-sialyltransferase (Cst-II)	<i>Campylobacter jejuni</i> ATCC 700297	n.d.	AF216647	AAL36462.1		
ORF	<i>Campylobacter jejuni</i> GB11	n.d.	AY422197	AAR82875.1		
$\alpha$ -2,3-sialyltransferase cstIII	<i>Campylobacter jejuni</i> MSC57360	2.4.99.-	AF195055	AAG29922.1		
$\alpha$ -2,3-sialyltransferase cstIII Cj1140	<i>Campylobacter jejuni</i> NCTC 11168	2.4.99.-	AL139077 NC_002163	CAB73395.1 NP_282288.1	Q9PNF4	
$\alpha$ -2,3/ $\alpha$ -2,8-sialyltransferase II (cstII)	<i>Campylobacter jejuni</i> O:10	n.d.	- AX934427	AAO96669.1 CAF04167.1		
$\alpha$ -2,3/ $\alpha$ -2,8-sialyltransferase II (CstII)	<i>Campylobacter jejuni</i> O:19	n.d.	AX934431	CAF04169.1		
$\alpha$ -2,3/ $\alpha$ -2,8-sialyltransferase II (CstII)	<i>Campylobacter jejuni</i> O:36	n.d.	AX934436	CAF04171.1		
$\alpha$ -2,3/ $\alpha$ -2,8-	<i>Campylobacter</i>	n.d.	AX934434	CAF04170.1		

FIG. 2M

Protein	Organism	EC#	GenBank / GenPept		SwissProt	PDB / 3D
sialyltransferase II (CstII)	<i>jejuni</i> O:4					
$\alpha$ -2,3/ $\alpha$ -2,8-sialyltransferase II (CstII)	<i>Campylobacter jejuni</i> O:41	n.d.	-	AAO96670.1 AAT17967.1 CAF04168.1		
$\alpha$ -2,3-sialyltransferase cst-I	<i>Campylobacter jejuni</i> OH4384	2.4.99.-	AF130466 -	AX934429 AAS36261.1	Q9RGF1	
bifunctional $\alpha$ -2,3/-2,8-sialyltransferase (Cst-II)	<i>Campylobacter jejuni</i> OH4384	2.4.99.-	AF130984 AX934425	AAF31771.1 CAF04166.1	1RO7 1RO8	C A
HI0352 (fragment)	<i>Haemophilus influenzae</i> Rd	n.d.	U32720 X57315 NC_000907	AAC22013.1 CAA40567.1 NP_438516.1	P24324	
PM1174	<i>Pasteurella multocida</i> PM70	n.d.	AE006157 NC_002663	AAK03258.1 NP_246111.1	Q9CLP3	
Sequence 10 from patent US 6503744	Unknown.	n.d.	-	AAO96672.1		
Sequence 10 from patent US 6699705	Unknown.	n.d.	-	AAT17969.1		
Sequence 12 from patent US 6699705	Unknown.	n.d.	-	AAT17970.1		
Sequence 2 from patent US 6709834	Unknown.	n.d.	-	AAT23232.1		
Sequence 3 from patent US 6503744	Unknown.	n.d.	-	AAO96668.1		
Sequence 3 from patent US 6699705	Unknown.	n.d.	-	AAT17965.1		
Sequence 34 from patent US 6503744	Unknown.	n.d.	-	AAO96684.1		
Sequence 35 from patent US 6503744 (fragment)	Unknown.	n.d.	-	AAO96685.1 AAS36262.1		
Sequence 48 from patent US 6699705	Unknown.	n.d.	-	AAT17988.1		
Sequence 5 from patent US 6699705	Unknown.	n.d.	-	AAT17966.1		
Sequence 9 from patent US 6503744	Unknown.	n.d.	-	AAO96671.1		

FIG. 2N

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US06/00282

## A. CLASSIFICATION OF SUBJECT MATTER

IPC: A61K 38/00( 2006.01)

USPC: 514/8

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
U.S. : 514/8

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
STN, EAST, Pubmed, Previous Related US Cases

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Ito, T et al., Synthesis of Bioactive Sialosides, Pure & Appl. Chem ; 1993, Vol. 65, No. 4, pages 753-762, see entire document.	1-18
A	US 5,405,753 (Brossmer et al) 11 April 1995 (04.11.1995), see entire document.	1-18

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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